AD_______________

Award Number: W81XWH-05-1-0393

TITLE: Cybertherapy 2005: A Decade of VR

PRINCIPAL INVESTIGATOR: Brenda K. Wiederhold, Ph.D.

CONTRACTING ORGANIZATION: Interactive Media Institute
San Diego, CA 92124

REPORT DATE: July 2005

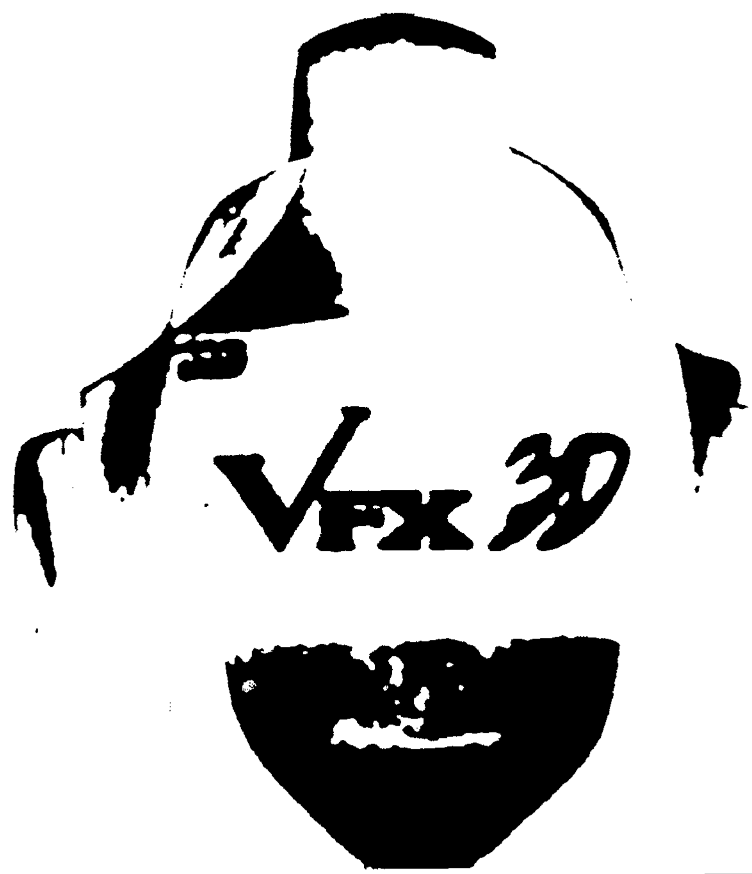
TYPE OF REPORT: Final Proceedings

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release; Distribution Unlimited

Annual Review of CyberTherapy and Telemedicine

Editors:
Brenda K. Wiederhold, Ph.D., MBA, BCIA
Giuseppe Riva, Ph.D., M.S., M.A.
Alex H. Bullinger, M.D., MBA



Publisher: Interactive Media Institute,
a 501c3 non profit organization
http://www.cybertherapyreview.com

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
01-07-2005

2. REPORT TYPE
Final Proceedings

3. DATES COVERED *(From - To)*
6 Jun 05- 10 Jun 05

4. TITLE AND SUBTITLE
Cybertherapy 2005: A Decade of VR

5a. CONTRACT NUMBER

5b. GRANT NUMBER
W81XWH-05-1-0393

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Brenda K. Wiederhold, Ph.D.

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Interactive Media Institute
San Diego, CA 92124

E-Mail: bwiederhold@vrphobia.com

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

No abstract provided.

15. SUBJECT TERMS
No subject terms provided.

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
U	U	U	UU	315	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

Annual Review of CyberTherapy and Telemedicine

Interactive Media in Training and Therapeutic Interventions

Editors-in-Chief

Brenda K. Wiederhold, PhD, MBA, BCIA
Interactive Media Institute, San Diego, CA, USA

Giuseppe Riva, PhD, MS, MA
Istituto Auxologico Italiano, Verbania, Italy

Alex H. Bullinger, MD, MBA
COAT-Basel, Basel, Switzerland

Interactive Media Institute

Annual Review of CyberTherapy and Telemedicine

6160 Cornerstone Court East
San Diego, CA 92121

ISBN: 0-9724074-7-2
ISSN: 1554-8716

Interactive Media Institute Website: www.interactivemediainstitute.com

General Information

Annual Review of CyberTherapy and Telemedicine (ARCTT – ISSN: 1554-8716) is published annually (once per year) by the Interactive Media Institute (IMI), a 501c3 non profit organization, dedicated to incorporating interdisciplinary researchers from around the world to create, test, and develop clinical protocols for the medical and psychological community. IMI realizes that the mind and body work in concert to affect quality of life in individuals and works to develop technology that can be effectively used to improve the standards and reduce the cost of healthcare delivery.

Interactive Media Institute, 6160 Cornerstone Court East, Suite 161, San Diego, CA, USA.

Telephone: (858) 642-0267, Fax: (858) 642-0285, E-mail: cybertherapy@vrphobia.com
IMI Web site: http://www.interactivemediainstitute.com

About the journal
ARCTT is a peer-reviewed all-purpose journal covering a wide variety of topics of interest to the mental health, neuroscience, and rehabilitation communities. The mission of ARCTT is to provide systematic, periodic examinations of scholarly advances in the field of CyberTherapy and Telemedicine through original investigations in the telemedicine and cybertherapy areas, novel experimental clinical studies, and critical authoritative reviews.

It is directed to healthcare providers and researchers who are interested in the applications of advanced media for improving the delivery and efficacy of mental healthcare and rehabilitative services.

Manuscript Proposal and Submission

Because Annual Review papers examine either novel therapeutic methods and trials or a specific clinical application in depth, they are written by experienced researchers upon invitation from our Editorial Board. The editors nevertheless welcome suggestions from our readers. Questions or comments about editorial content or policies should be directed to the editors only.

Manuscript Preparation
Manuscripts should be submitted in electronic format on CD-Rom or floppy disks as well as on 8½ x 11-in. paper (three copies), double-spaced format. Authors should prepare manuscripts according to the *Publication Manual of the American Psychological Association* (5th Ed.).

Original, camera-ready artwork for figures is required. Original color figures can be printed in color at the editors' discretion and provided the author agrees to pay in full the associated production costs; an estimate of these costs is available from the ARCTT production office on request.

ARCTT policy prohibits an author from submitting the same manuscript for concurrent consideration by two or more publications. Authors have an obligation to consult journal editors concerning prior publication of any data upon which their article depends. As this journal is a primary journal that publishes original material only, ARCTT policy prohibits as well publication of any manuscript that has already been published in whole or substantial part elsewhere, unless authorized by the journal editors.

Disclaimer
All the published papers, editorial news and comments, opinions, findings, conclusions, or recommendations in ARCTT are those of the author(s), and do not necessarily reflects or constitute the opinions of the Journal, its Publisher, and its editorial staff.

Table of Contents

ORIGINAL RESEARCH

CLINICAL OBSERVATIONS

Editorials

Welcome to the third volume of *Annual Review of CyberTherapy and Telemedicine*. A decade ago, CyberTherapy, then still in its infancy, only existed as a specialized Virtual Reality and Behavioral Healthcare Symposium at the Medicine Meets Virtual Reality (MMVR) Conference. At that first session, Dr. Ralph Lamson presented a small study on virtual reality (VR) exposure for treatment of acrophobia in ten participants. It is now clear that in 1996, we had only begun to realize what promise might lie ahead for both VR technology and the CyberTherapy Conference.

Much has changed over the past ten years and we have now tapped further into VR's potential than many of us could have ever imagined. Today, researchers from around the world are busy completing hundreds of trials, applying VR for such varied disorders as Anxiety, Eating Disorders and Obesity, Addictions, Erectile Dysfunction, Autism and Schizophrenia. In addition, VR for Neurorehabilitation and Physical Rehabilitation has shown definite success, as has VR for other such diverse areas as Pain Distraction (both acute and chronic), Education, Training, and Physical Disabilities.

I am proud to report that as VR's use in Behavioral Healthcare has grown, so has the CyberTherapy Conference. What began as a specialized symposium at MMVR concerned mainly with conceptual matters, has now grown into the largest program on controlled clinical trials of VR and other advanced technologies in the areas of behavioral healthcare, rehabilitation, disabilities, education, and training.

Along with my colleagues in the VR community, the conference's focus has expanded from simply VR to now include such cutting-edge technologies as robotics, non-invasive physiological monitoring, videogames, E-health, and adaptive displays. CyberTherapy 2005 (CT05) represents a group of outstanding international researchers and clinicians working tirelessly to improve our understanding of how advanced technologies can improve 21st century healthcare. In addition to bringing together the best clinicians and researchers from various disciplines, it is our specific intention to also facilitate their introduction to representatives from funding agencies interested in providing support for advanced technologies and healthcare.

In celebration of a decade of CyberTherapy, this year's Annual Review encompasses a state-of-the-art collection of clinical trials with an eye on the future of advanced technologies for health care. In this way, I hope that this collection can serve as a catalyst to improve the quality of life of the patients we seek to serve, and ultimately allow society to benefit from the remarkable technological revolution that is occurring.

I hope you find this volume to be both an exciting and useful addition to your bookshelf.

Sincerely,

Brenda K. Wiederhold, Ph.D., MBA, BCIA
Co-Editor-in-Chief

Editorials

Since 1986, when Jaron Lamier used the term for the first time, virtual reality (VR) has been usually described as a collection of technological devices: a computer capable of interactive three-dimensional (3D) visualization, a head-mounted display, and data gloves equipped with one or more position trackers. The trackers sense the position and orientation of the user, and report that information to the computer that updates (in real time) the images for display.

In medicine many researchers share this vision: VR is a collection of technologies that allow people to interact efficiently with 3D computerized databases in real time using their natural senses and skills.

However, if we shift our attention to behavioral sciences, we find a different vision: VR is described as an advanced form of human–computer interface that allows the user to interact with, and become immersed in a computer-generated environment in a naturalistic fashion.

In fact, psychologists use specialized technologies - head-mounted displays, tracking systems, earphones, gloves, and sometimes haptic feedback - to develop and provide a new human–computer interaction paradigm. In VR, patients are no longer simply external observers of images on a computer screen, but are active participants within a computer-generated 3D virtual world. This approach is clearly detailed in many papers of this issue: VR is used as an advanced communication interface based on interactive 3D visualization, able to collect and integrate different inputs and data sets in a single real-like experience.

This point underlines the importance of the therapeutical relationship for the efficacy of most of the approached presented: VR is a tool augmenting the possibility of relation and interaction between the therapist and the patient. However, many psychotherapists still think that in technology supported treatments, and in particular in VR therapy, there is no place for a therapeutic relationship.

To allow a widespread diffusion of communication technologies real clinical practice is critical both to counter this prejudice, and to offer training courses helping therapists in understanding how to integrate technologies in their own approach and methods.

Giuseppe Riva, Ph.D., M.S., M.A.
Co-Editor-in-Chief

Editorials

In 2005, It has been my pleasure not only to co-organize the first of what promises to be a long line of internationally held *CyberTherapy Conferences* here in Basel, Switzerland, but also to help celebrate the conference's tenth anniversary! Once again, I would like to use this opportunity to I extend a warm welcome, or as we say here in Switzerland, a warm "Grüzi", to all attendants.

As co-organizer of this year's meeting, it has also been my pleasure to serve as one of the Annual Review of Cybertherapy and Telemedicine's esteemed board of editors. This year's Cybertherapy was organized as a joint conference together with the *1st International Conference on Applied Technologies in Medicine and Neuroscience* and I expect a fruitful interdisciplinary gathering of many interested researchers, clinicians and engineers alike. I do believe that the change in venue for the meeting has served to attract an even more diverse number of researchers from around the world and led to a most impressive number of submissions for this year's Annual Review.

I would like to thank especially Brenda K. Wiederhold and the Interactive Media Institute for making this joint conference possible. Thanks also to Stéphane Bouchard who with utmost efficiency organized the workshops. And finally, a special thanks goes to all those who submitted papers and posters, to all participants as well as to the members of the program committee.

We all hope for an exciting conference that all of you will enjoy attending!

Sincerely,

Dr. Alex H. Bullinger, MBA
Co-Editor-in-Chief

Critical Reviews

Motivational Training Tool to Promote Healthy Life Styles

N. Fernández M.Sc., E. del Hoyo Barbolla M.Sc., C. Ramírez M.Sc., R. de las Heras M.Sc., M. T. Arredondo F.P., Ph.D.

Life Supporting Technologies, Telecommunication Engineering School, Technical University of Madrid, Spain

Abstract: *The aim of the project is to apply augmented-reality technology to teach motor skills to patients suffering from stroke. To achieve this goal the project adopts an innovative approach based on the use of so-called "motor imagery." Recent studies in neuroscience have provided converging evidence that "imagining" a motor action involves the same brain areas involved in performing the action. This supports the idea – already exploited by sports trainers – that training with motor imagery (mental practice) could be effective in learning new motor skills or in promoting motor recovery after damage to the central nervous system. Previous clinical studies have shown that the rehabilitation of post-stroke hemiplegic patients can be made more effective by combining physical practice with mental practice. However, for many patients who suffer from damage to the central nervous system, mental simulation of movements can be difficult, even when the relevant neural circuitry has not been injured. Starting from these premises, we have designed and developed an augmented-reality workbench (called "VR Mirror") to help post-stroke hemiplegic patients evoking motor images. First, the movement is acquired by the system from the healthy arm. Second, the movement is being mirrored and displayed so that the patient can observe and see as if the impaired arm is performing the movement. Third, the patient is instructed to rehearse in his/her imagination the movement he/she has just observed. Last, the patient has to perform the movement with the affected arm. In this article, we describe preliminary results of a pilot clinical study, which has evaluated the feasibility of using technology-supported mental simulation as an adjunct in the rehabilitation of the upper limb following stroke. DESIGN: Single-case study. SETTING: Physical Rehabilitation Unit of Padua Teaching Hospital, Padua, Italy. SUBJECTS: A 46-year-old man with stable motor deficit of the upper right limb following stroke. INTERVENTION: The patient underwent a single-case design, with four weeks intervention. The intervention consisted of 3 practice sessions per week at the hospital using the VR-Mirror, in addition to usual therapy (Bobath method). This intervention was followed by 1-month home-rehabilitation program using a portable device. MAIN OUTCOME MEASURES: The patient was evaluated for level of impairment and disability. Pre-treatment and post treatment measures included: the upper-extremity scale of the Fugl-Meyer Assessment of Sensorimotor Impairment and the Action Research Arm Test. RESULTS: The patient showed improvement in upper limb score as measured by the two scales. CONCLUSIONS: The improvement observed in the patient is encouraging and warrants further study.*

INTRODUCTION

One of the main challenges that developed societies face is the prevention of non-communicable diseases such as diabetes or obesity. These diseases are responsible for 60% of the registered global deaths and for 45% of the global burden of disease. A few, largely preventable, risk factors account for most of the world's disease burden. These are high cholesterol, high blood pressure, obesity, smoking and alcohol. Chronic diseases are the major cause of death and disability worldwide, and increasingly affect people from countries all over the world.[6]

Guidelines on diet, physical activity and health serve two important purposes: to guide policy makers and to educate consumers, about healthful lifestyles. In order to promote prevention and create motivation and adherence to the prevention programmes it is highly recom-

mended to stress the importance of lifestyle-health relationship. And it is also essential to analyse in depth how to formulate these programmes and what the process and information they should convey. The strategies drafted by the international institutions competent in this matter stress the importance to increase the overall awareness and understanding of the influences of diet and physical activity on health and of the positive impact of preventive interventions.

The work presented in this paper contributes partially to solve this situation by using one of the most effective strategies: the prevention, through the procedure of education. In this sense, providing users with personalised information is key to be able to adhere them to the prevention strategy. More than that, the new healthcare delivery process models tend to be citizen/patient centred, that are respectful of the individual preferences, needs and values and place information and training at the heart of the healthcare delivery strategies.[2]

An interactive and visual tool based on virtual 3D technologies for the Internet,[5] using X3D, a powerful and extensible open file format standard for 3D visual effects, has been developed and integrated in an e-learning system that offers personalised information about healthy lifestyles.

MATERIALS AND METHODS

The tool implemented intends to give answers to the situation referred above by offering the users personalised information for their own self-care and moreover, motivating them to make use of this information and take control over their decisions regarding their lifestyle. Personalised information makes users more independent, makes them conscious of the possible results due to their behaviour and facilitates them to take care of their own health. In this sense, the development of a virtual reality tool helps to motivate the user and also improves the e-learning process.[1]

The main contribution of the implemented system is the delivery of personalised information in an adapted environment. This goal has been achieved by the integration of several technologies such as XML, native databases, X3D, VRML or JSP (Java Server Technology). These technologies have been chosen taking into account the interactive, portable, visual and integrative identified requirements for the tool. Furthermore, these technologies allow the possibility of introducing some kind of intelligence to the tool behind the interface in order to obtain a system that could respond to the individual user needs and preferences.

The complete process has been divided into four different stages. Therefore, in each step, a group of technologies has been selected to achieve the required functionalities for the whole system. These stages are: Profiling, Storage, Personalisation & Management. The next paragraphs describe these four stages:

The Profiling stage helps to acquire individual user information, to structure it and hence, to define what the user needs are. The system is designed to be accessed through the Internet. The registration and the questionnaires about nutritional, statistical, physical activity and motivational data have been developed with JSP. The goal of these questions is to define a user profile and to discover his motivation status according to the "States of Change" methodology.[3] The methodology sets the characteristics to be classified in each state of change and the motivational techniques to be used for citizens.

The Storage stage responds to the need of storing the user profiles and the information to be shown in the system. Each profile is stored as an XML file in the native database. The scenarios have been developed in X3D. This allows describing a virtual world in XML by means of predefined tags representing objects. The scenarios are virtual worlds that simulate the "real world" and daily activities. However, as the X3D plug-in was not compliant with the X3D standard at the development time, the display of the sessions is performed by using VRML (an X3D antecedent). Translations between the two languages are made by applying a style sheet to the X3D files in their XML format.

The Management stage is necessary in order to maintain the static information used by the system.

Finally, **the Personalisation** stage carries out the process of adapting the system to the users.

At the time the user profile is created or modified (either by the user or by the intelligence added to the system), the scenarios are personalised to meet the user preferences and are completed with the information that suits the user needs most and they are stored in the system. These tasks involve reading and writing XML files by means of a XML parser. It is used a SAX (Simple API for XML) parser because of its speed and straightforward features. Once the personalised worlds have been created, they are stored.

RESULTS

The tool implemented has been developed to present the following features:

- To offer personalised information in form and content
- To be visual and interactive
- To be integrated in an e-learning system

In this sense, a training activity in the system consists of an Internet multimedia session that shows personalised information by means of an attractive visual interface. The session starts by choosing the users a login and a password for identification and introducing their data. The user profiles are created the first time the user accesses the system by filling in a structured questionnaire about nutritional, statistical, motivational and physical exercise. Each group of questions has a specific objective: the statistical questions try to classify the users per age, gender, health status, ICT knowledge or profession. Nutritional questions try to enquire if the users are vegetarian or if it is common that they often eat out in order to prepare a customised diet. Motivational questions are related to the importance the users give to their self-care through the lifestyle adopted up to the moment or the intentions to incorporate healthier attitudes in the future (i.e., intention to lose weight, to practise any sport, etc).

In subsequent accesses the users must enter the login and password to be recognised by the system as registered users and this way, skipping the questionnaires and be led directly to the welcome page where they can choose either starting their training session or modifying their data.

The personalisation of the scenarios involves presenting different information (links, articles, recipes, sport videos, etc.) to each user profile. In order to perform the personalisation, the system accesses the database and extracts the model files stored in. The user session "world" is then created from this pattern and is filled in according to the user needs. Adapting the information includes not only the content but also the form (i.e. tone in which it is presented, ways in which the information is shown to the user). This depends strongly on the user motivation state[4] to follow advice and to adopt changes to a healthier lifestyle which was identified in the profiling stage. In this sense, only the relevant information in the appropriate mode (direct, indirect, soft, etc.) is delivered to the user through a scenario personalised accordingly (avatar, colours, links, etc.).

The database has been hierarchically structured in three collections (similar to directories): profiles, patterns and information. The most important is the first of them and it is due to be dynamically changed every time a new user accesses the system by storing the user profile and creating a user collection under it. In the user collection, called as the user login, the personalised scenarios are stored. In this way, if the user has not introduced any change in their data from the previous session, the system accesses the adapted scenarios and displays them to the user, thus, saving time and resources. The other collections, patterns and information, contain static data such as scenarios models or information to be shown to the user. The pattern collection stores the scenarios models files. Each of these files contains the common information, which is shared between all the users in a specific scenario, such as images or help links. The second collection (information) stores data related to health care in different modes, depending on the needs the user has. The corresponding information will be selected during the personalisation stage depending on the user needs and motivation.

The files stored in these collections can be modified by the administrator in order to improve the system quality, by adding new infor-

mation or modifying the existing one; adding new features to the scenarios or readapting the ones stored in previous sessions. It is important to notice that changes to the data and scenarios will not affect the users due to the models usage to generate the personalised worlds. In this way, the next session the users establish with the system, the scenarios ("worlds") shown to them will include the changes performed and the new added or modified information if it is relevant to them.

The tool is completely developed and personalization features are included, a process we started working together with healthcare professionals. Different users´ profiles have been identified.

The tool has been tested with a number of users to check whether the tool and the information provided suited the users' needs. A survey was handed out for completion after the first training session in order to measure their satisfaction with the system. The survey is structured in different parts which are related to the adaptability of the contents, the appropriateness of the relation between the scenarios and the information showed in each of them, the choice of Virtual Reality as the interface and the usability of the global tool. Statistical data were also collected, such as the age, the job or the computer knowledge level.

The results of the survey indicate that Virtual Reality is an unknown technology yet although it presents high potential for the implementation of e-learning systems. Elderly people value it quite negatively opposed to the students and technical professionals. A similar answer is also given to the usability of the global tool due to the strong dependence this aspect has with the ability of handling Virtual Reality. However, the users state that the relation between the scenarios developed and the information provided in each of them was tailored to their needs and the contents were marked as a good educational tool to adopt a healthy lifestyle.

CONCLUSIONS

An interactive and visual tool has been developed and integrated in an e-learning system that offers personalised information about healthy lifestyles. We consider that this is a very interesting research line due to the increase of e-learning systems and the importance of having access to quality information related to health. Joining both in the same system provides citizens with a way to obtain information to possible them to be responsible for their own health. People should have better access to trusted sources for the information they need, tailored to their individual requirements. In this way, the implemented tool goes further by adding a motivational feature with the aim of making users feel taking control of their own self-care.

To conclude, the tool developed provides certified information and achieves personalisation by considering different dimensions of people's lifestyle and filtering the information according to:

- Who the user is: a Healthcare professional, a Citizen, etc.
- What the user needs: different information or services the user may need
- Where the user is: considering different scenarios, including "on the move"
- How the user needs the service: considering different type of devices

However, the tool has strong requirements to perform in an acceptable way. In this sense, it may be a solution to try to adopt more dynamic software in order to be able to include it in other devices such as mobile phones or PDAs that facilitate the information access in active lifestyles.

ACKNOWLEDGMENTS

We appreciate the information provided by Dr. Claudia Duarte and Joy Ngo de la Cruz from GRNC (Group de Reçerca de Nutrició Comunitaria) for their time and advice to make our system more complete and qualified.

REFERENCES

Gutiérrez, J., 2002. Aplicaciones de la realidad virtual en Psicología clínica. Aula médica psiquiatría, 4 (2), 92-126.

NHS, 2004. Department of Health. Better information, better choices, better health. Putting

information at the centre of health.

R. Prochaska, J.O., & DiClemente, C.C. (1982). Transtheoretical therapy toward a more integrative model of change. Psychotherapy: Theory, Research and Practice, 19(3), 276-287.

UCLA Center for Human Nutrition. Sample Scripts for Stages of Change http://www.cellinteractive.com/ucla/physcian_ed/scripts_for_change.html.%201996.

Web 3C Consortium. http://www.web3d.org.

WHO (2004) Guidelines on diet, physical activity and nutrition. http://www.who.int/gb/ebwha/pdf_files/WHA57/A57_R17-en.pdf.

CONTACT

Natalia Fernández
E.T.S.I.Telecomunicación. Ciudad Universitaria
Universidad Politecnica de Madrid
Phone: +34 91 549 57 00 ext. 332
Fax: +34 91 336 68 28
Email: nfernandez@gbt.tfo.upm.es

Real Time Changing Virtual Environments: A New Tool for Virtual Therapy

M. Alcañiz, Ph.D., B. Rey, M.Sc., J. Montesa, M.Sc., J. A. Lozano, Ph.D., M. C. Juan, Ph.D.

Medical Image Computing Laboratory (MedICLab), Technical University of Valencia

Abstract: *Environments used up to now for therapeutic applications are invariable ones whose content cannot be changed by the therapist or by the patient. However, this is a technical issue that can be solved with current technology. In this paper, we describe a virtual environment that has been developed taking into account this factor. The main technical feature of the environment is that its aspect can be controlled and modified by the therapist that conducts the clinical sessions depending on the emotions that the patient is feeling at each moment.*

The applications of these dynamic changes are not limited to the field of clinical psychology. They open a new arena of possibilities for many other kinds of applications including industry, architecture, medicine etc. The virtual environment that is described in this paper is a step towards a truly adaptive display.

INTRODUCTION

The concept of "adaptive displays" has been considered for many years. It is the use of technical devices that adapt to the requirements of the user, rather than having the users adapt to the device. The term "adaptive display" has referred to displays that change their contents depending only on situational content rather than on any awareness of the user.[1] These adaptive displays can be used in many different applications such as medicine, industry, architecture, and psychology.

In the field of clinical psychology, virtual reality has in recent years been applied to the treatment of psychological disorders. This idea was first voiced in November 1992 in the Human-Computer Interaction Group of the Clark Atlanta University. The first experiment was a pilot study with a 32-years-old woman who suffered from flying phobia. She was treated using a virtual environment[2] in which she followed eight thirty-minute sessions. At the beginning of each session, the subject had a high level of anxiety, which was decreasing gradually after remaining in the situation for several minutes. This effect also was transferred from the virtual to the real world.

Since this initial study, this technique has been used for the treatment of different phobias. We can point out the environments designed for acrophobia treatment,[3-5] agoraphobia,[6,7] spider phobia[8] or flying phobia.[9,10] Its effectiveness has been analyzed for the fight against other psychological problems: obsessive-compulsive disorders, attention deficit disorders, post-traumatic stress and eating disorders.[11,12]
However, environments used up to now for therapeutic applications are invariable ones whose content allows for only minor changes. As a result, no modification can be made in the contents of the virtual environment even when high emotional responses can be obtained from the user. It is our claim, that the psychologist should have a greater control over the aspect of the virtual environment that is shown to the user.

In the environment that we are presenting in this paper, the psychologist can make changes in the aspect of the environment depending on the reactions of the patient to different parts of the therapy session. This work has been conducted inside the EMMA Project (IST-2001-39192).

DESIGN OF THE VIRTUAL ENVIRONMENT

The purpose of the virtual environment is to be used in the context of a psychological treatment. The user is a person who suffers from psychological problems, such as affective disorders, anxiety disorders or adjustment disorders. All treatment sessions are conducted by a therapist and the virtual environment is used as an aid for this treatment. Both the therapist and the patient are physically present in the room during the evolution of the session.

The patient visualizes the virtual environment in a retro-projected screen, and the interaction is made by means of a wireless joystick.

The application has been developed using Brainstorm eStudio software. This is an advanced, multiplatform real time 3D graphics development tool. It incorporates features such as: the easy inclusion of 3D objects imported from files, erased or animated; generation of 3D texts, whose colors can be changed; adding videos to surfaces; generation of new interfaces and timers; addition of actions to objects when they are selected; addition of sounds; loading or saving configurations. All these possibilities are controlled using the mouse, pop-up menus or drag and drop actions. The interpreted language that is used to program is python. Brainstorm eStudio can be defined as an interface that the programmer can use to create 3D complex visualizations using only tool options.

DESCRIPTION OF THE ENVIRONMENT

The environment can be modified dynamically by the therapist taking into account the state of the patient at each moment during the treatment, so different aspects have been developed. The environment is not a static one. Initially, the user appears inside a big circular-shaped hall with no walls.

The user can visualize the outer part of the environment, which initially is an open area of meadows. The user can navigate freely along the entire environment, even leave the big hall and walk through the meadows.

However, the meadows constitute only one of the five possible aspects of the outer part of the environment. The other pre-defined aspects are: a desert, an island, a forest with many trees and branches, and a snowed city. These five environments can be related to different emotions. For example, the forest with braches can be related to anxiety. On the other hand, if the purpose of the therapist is to induce relaxation in the patient, the island can be used. The desert can be related to rage, and the snowed city with sad situations, so it can be used during the session when the patient is remembering a situation that induces sadness in him or her. The use of each aspect of the environment depends on the context of the session and can be selected by the therapist in real time.

In order to control the appearance of the different aspects that have been developed, a spe-

Figure 1. Aspect of the room.

Figure 2. Virtual environments corresponding to anxiety and joy

cial interface has been prepared. The application is running on a computer separate from the one where the virtual environment has been launched. The therapist can easily select (pressing different buttons) the aspect of the environment that has to be shown at each moment, and the needed command will be sent using TCP/IP to the computer where the environment is running. As soon as this computer receives the command, the appearance of the environment will change depending on the concrete order that it has received.

APPLICATION OF SPECIAL EFFECTS

Besides the big-scale control that we have described in the previous point, the therapist can also control small-scale changes. Different ef-

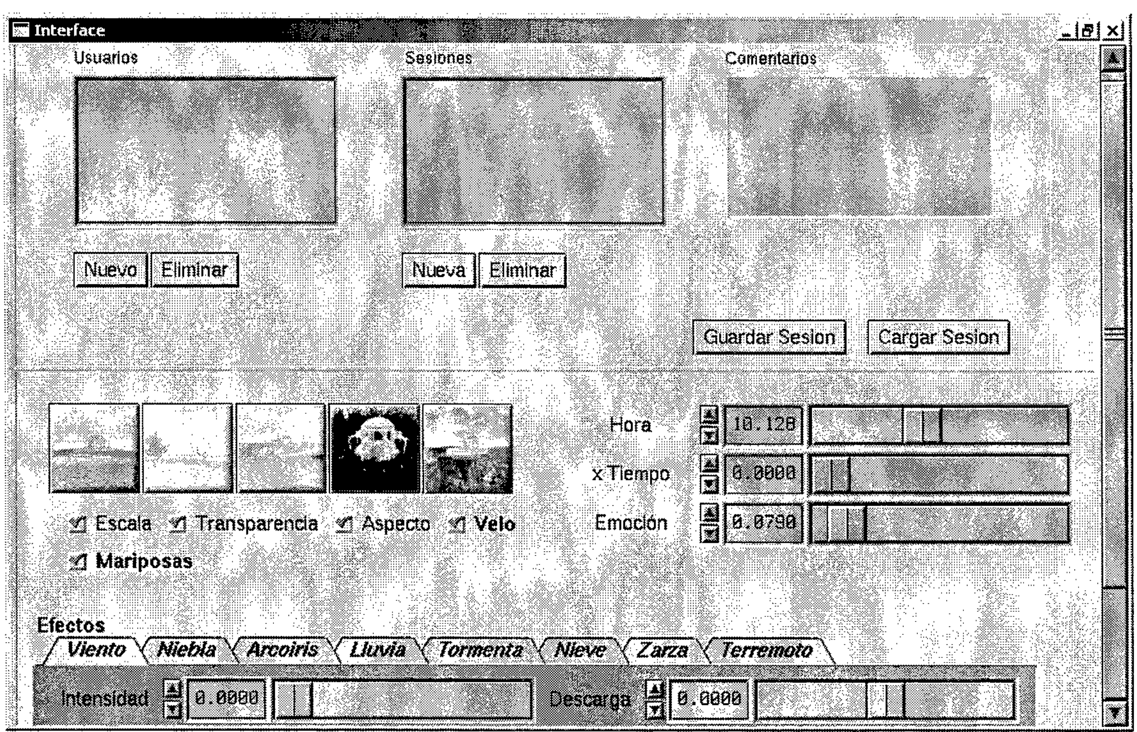


Figure 3. Interface for the therapist

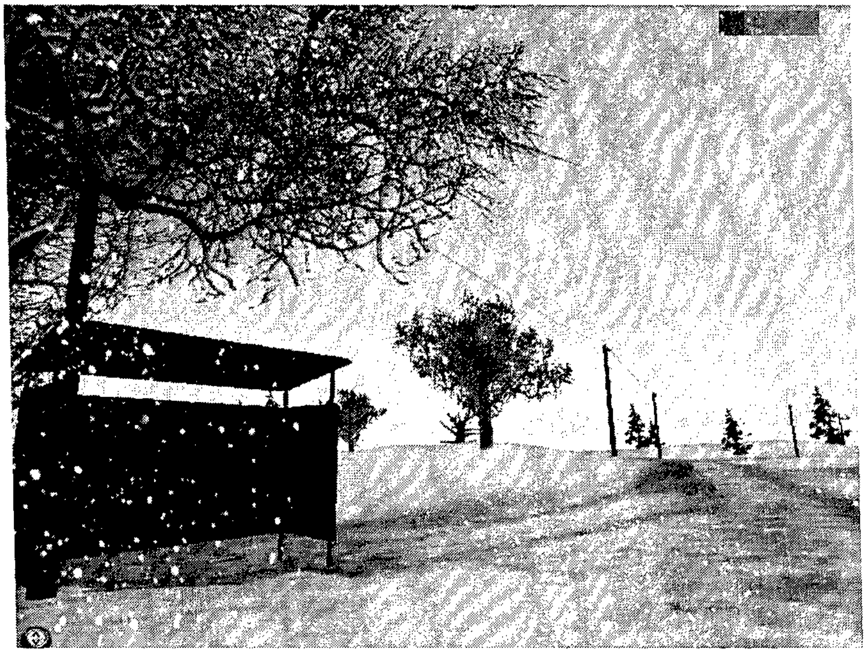


Figure 4. The sad environment snowing and with a storm.

fects can be applied to the environment: a rainbow can appear, it can start raining, snowing, an earthquake can be generated, and the illumination can change to the one corresponding to different hours of the day and the night.

All these effects are also launched from the same interface that controls the big-scale changes. The therapist can control by means of a slider the moment when the effect is launched and its intensity.

OTHER INTERACTIONS

But it is not only the therapist who can control the personalization of the environment. The user can also play an active role on this task.

The big hall that is present in any of the possible aspects of the virtual environment is composed by different systems that interoperate and allow the patient to express ideas using different items (videos, images, sounds, colors and 3D objects) that can be selected from a database.

Distributed along the environment, there are several places (object holders) where the patient can locate an item from the database, so the 3D aspect of the element will be shown, or the associated sound or video will be reproduced. This can be used as a way to personalize the environment. These object holders can serve as a mixer tool to combine several elements to form a new complex element. This is achieved if different elements from different categories are copied to the same object holder. There are some special object holders that are placed in a balcony of the room. The patient can modify the size of the objects that are placed on them by means of the loudness of the voice. They will be used as a discharge area where the patient can give free rein to his/her feelings. A system has been programmed that detects the loudness of the input sounds and modifies accordingly the size of the objects placed on those special object holders.

The living book is a special object where the patient can place icons that represent the elements from the database. These icons can be classified in different chapters. It is the instrument that the patient will use to put in order the contents that have been used during the clinical session with the therapist.

Finally, the drain can be used to destroy any element that is not needed anymore.

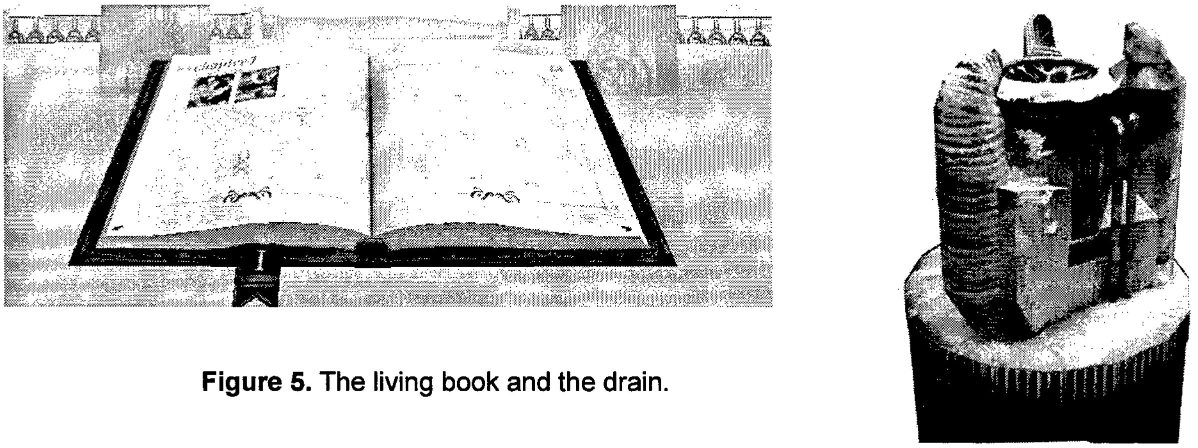


Figure 5. The living book and the drain.

CONCLUSIONS

Using this new technical approach, different environments can be developed to treat different kinds of psychological problems. The possibility of dynamically changing the aspect of the environment, which is the main improvement of this system from the technical point of view, opens a new area and new possibilities for treating psychological disorders.

Besides, this system constitutes a step forward towards a true adaptive display. The ultimate purpose would be that the system itself would be able to detect the emotional state of the user and adapt its contents to this state without any intervention from the therapist.

REFERENCES

1. Schmeisser, E.T. Dream of a Display that Pays Attention to the Viewer. CyberPsychology & Behavior 2004; 7(6): 607-609.

2. North, M.M., North, S.M. y Coble, J.R. Virtual environment psychotherapy: a case study of fear of flying disorder. Presence: Teleoperators and Virtual Environments 1997; 6 (1): 127-132.

3. North M., North S. Virtual reality psychotherapy. The Journal of Medicine and Virtual Reality 1996; 1: 28-32.

4. Rothbaum, B., Hodges L., Kooper R., Opdyke D., Williford M., North M. Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. American Journal of Psychiatry 1995; 152: 626-628.

5. Rothbaum B., Hodges L., Kooper R., Opdyke D., Williford M., North M. Virtual reality graded exposure in the treatment of acrophobia: A case report. *Behavior Therapy* 1995; 26: 547-554.

6. North M., North S. Virtual environments and psychological disorders. Electric Journal of Virtual Culture 1994; 2: 25-34.

7. North M., North S., Coble J.R. Effectiveness of virtual environment desensitization in the treatment of agoraphobia. Presence *1996;* 5(3): 346-352.

8. Carlin A., Hoffman H., Weghorst S. Virtual reality and tactile augmentation in the treatment of spider phobia: A case report. Behavior Research and Therapy 1997; 35: 153-158.

9. Rothbaum B., Hodges L, North M., Weghorst S. Overcoming phobias by virtual exposure. Communications of the ACM 1997; 40: 34-39

10. Baños R., Botella C., Perpiñá C. (2000). El abordaje de la fobia a volar mediante realidad virtual (Approach to flying phobia by virtual reality). *Communication presented at the IX Meeting of the Psychiatric Association of the Comunidad Valenciana*, Castellón, Spain.

11. Riva G., Baccheta M., Cesa G., Conti S., Molinari E. (2001) Virtual Reality and Telemedicine Based Experiential Cognitive Therapy: Rationale and Clinical Protocol. In: Fiva G, Galimberti C., eds. *Towards CyberPsychology: Mind,*

Cognitions and Society in the Internet Age. Amsterdam: IOS Press.

12. Perpiñá C., Botella C., Baños R., Marco J.H., Alcañiz M., Quero S. Body Image and virtual reality in eating disorders: Is exposure by virtual reality more effective than the classical body image treatment? Cyberpsychology and Behavior 1999; 2: 149-159.

CONTACT

Mariano Alcañiz, Ph.D.
Medical Image Computing Laboratory (MedICLab)
Technical University of Valencia
Camino Vera s/n
46022 Valencia (Spain)
e-mail: malcaniz@degi.upv.es
Telephone: +34 96 387 75 17
Fax: +34 96 387 95 10

Towards a Neuropsychological Basis of Presence

W. IJsselsteijn, Ph.D.

Human-Technology Interaction Group, Eindhoven University of Technology, Eindhoven, The Netherlands

Abstract: *Presence research studies the experience of being in a place or being with someone as it is mediated through technology. The experience of presence appears to be a complex perception, formed through an interplay of raw multisensory data, spatial perception, attention, cognition, and motor action, all coupled through a constant dynamic loop of sensorimotor correspondence. The fact that technology can start working as a transparent extension of our own bodies is critically dependent on (i) intuitive interaction devices which are 'invisible-in-use', seamlessly matched to our sensorimotor abilities, and (ii) the highly plastic nature of our brain, which is continuously able and prone to adapt to altered sensorimotor contingencies. The perception of ourselves as part of an environment, virtual or real, critically depends on the ability to actively explore the environment, allowing the perceptual systems to construct a spatial map based on sensorimotor dependencies. Provided the real-time, reliable correlations between motor actions and multisensory inputs remain intact, the integration of telepresence technologies into our ongoing perceptual-motor loop can be usefully understood as a change in body image perception – a phenomenal extension of the self.*

INTRODUCTION

Interactive systems that allow users to control and manipulate real-world objects within a remote real environment are known as *teleoperator* systems. Remote-controlled manipulators (e.g., robot arms) and vehicles (e.g., NASA's Mars Exploration Rovers) are being employed to enable human work in hazardous or challenging environments such as space exploration, undersea operations, or hazardous waste clean-up. They also allow for transforming the temporal and spatial scale of operation, as is the case with for instance minimally invasive surgery. In teleoperation, the human operator directly and continuously guides and causes each change in the remote manipulator. Sensors at the remote site (e.g., a stereoscopic camera, force sensors) provide continuous feedback about the slave's position in relation to the remote object, thereby closing the continuous perception-action loop that involves the operator, the master system with which she interacts locally, and the remote slave system. In the context of telerobotics, telepresence is closely associated to the sense of *distal attribution*,[1] the externalisation of the self to include remote tools that phenomenologically become extensions of one's own body, even if they are not physically part of it.

Whereas teleoperation systems enable the manipulation of remote real-world environments and objects within it, virtual environments (VEs) allow users to interact with synthetic or computer-generated environments. In its most well-known incarnation, VEs are presented to the user via a head-mounted display (HMD) where visual information is presented to the eyes via small CRTs or LCDs, and auditory information can be presented using headphones. Importantly, the HMD is fitted with a position tracking device which provides the necessary information for the computer to calculate and render the appropriate visual and auditory perspective, congruent with the user's head and body movements. Haptic information, although not yet usually included in present-day VEs, can be added through the use of for instance an exoskeletal glove or arm, acting both as sensor and actuator.

Telepresence (in relation to teleoperation) and virtual presence (in relation to VEs) both address the psychological phenomenon of *presence* – the sense of 'being there' in a mediated environment, or a "perceptual illusion of non-mediation" as Lombard and Ditton[2] defined it. Perceived transparency of the medium is crucial, i.e. a sense of direct perceptual stimulation and potential for action, without an awareness of the remoteness in time or space of the simulated or reproduced realities.

MEDIA CHARACTERISTICS INFLUENCING PRESENCE

Since the early 1990s onwards, presence has been empirically studied in relation to various media, most notably VEs. A large number of factors that may potentially influence the sense of presence have already been suggested in the literature. Depending on the levels of appropriate, rich, and consistent sensory stimulation, varying levels of presence can be produced. Sheridan[3] proposed three categories of determinants of presence:

- The extent of sensory information presented to the participant, i.e. the amount of salient sensory information presented in a consistent manner to the appropriate senses of the user.
- The level of control the participant has over the various sensor and interface mechanisms (tracked HMD, dataglove, etc.). This refers to the various sensorimotor contingencies, i.e. the mapping or correlation between the user's actions and the perceptible spatio-temporal effects of those actions.
- The participant's ability to modify the environment, i.e., the ability to interact with the virtual or remote environment and to affect a change within that environment.

The extent of sensory information is similar to Steuer's[4] notion of *vividness*. Level of control over sensors and effectors, and the ability to modify the environment correspond to Steuer's[4] notion of *interactivity*. These three factors all refer to the media *form*, that is, to the physical, objective properties of the media technology. Importantly, presence research is about relating those media form variables to the human response. In principle, Slater's[5] contention that one should try to keep content variables out of the presence equation as much as possible is adopted here. According to Slater,[5] "presence is about form, the extent to which the unification of simulated sensory data and perceptual processing produces a coherent 'place' that you are 'in' and in which there may be the potential for you to act."

It is of clear theoretical and practical value to establish what the optimal mix of cues might be for different application contexts, or, if the optimum is unattainable, which elements are most critical to the experience of presence. It appears, for instance, that pictorial realism contributes less to the experience of presence in VEs than, for instance, interactivity of viewpoint.[6] As Heeter[7] noted, "the alchemy of presence in VR is in part a science of tradeoffs." It is not clear at present how much each feature or perceptual cue contributes to eliciting a sense of presence for the participant (i.e., the relative weighting), nor is it clear how these cues interact with each other. A model of multisensory information integration and interaction for presence - a *presence equation*, if you like - will be a valuable theoretical and practical contribution. Ellis[8] has argued that an equation relating presence to its contributing factors should allow for iso-presence equivalence classes to be established, that is, maintaining the same level of measured presence, whilst trading off contributing factors against each other. However, testing such a model's empirical validity will critically depend on sufficiently reliable, valid, and sensitive measures of presence which are currently being researched (for an overview see van Baren & IJsselsteijn, 2004;[9]), but can not yet be said to exist at this point in time.

ESTABLISHING SENSORIMOTOR DEPENDENCIES THROUGH ACTIVE EXPLORATION

Perception serves the individual's need to control relevant moment-to-moment behaviour or action within a changing environment. The development of visual perception of object shape and environmental layout is strongly dependent on consistent correlations between vision and input from other sensory systems (mainly touch and kinesthetics) through active exploratory behaviour of the environment, establishing a stable yet flexible multisensory representation of space.

In a classic study, Held[10] convincingly demonstrated the relation between locomotor experience and the understanding of spatial relations. He designed an experiment using a 'kitten carousel' in which kittens, who were raised from birth in total darkness, were placed in pairs. One kitten pulled the carousel, thus using its movement to determine what it saw. The other kitten was placed in a basket at the other end of the carousel, which was controlled by the first

kitten. In this way, the second kitten received identical visual stimulation to the first kitten, yet without the ability to control the visual input. Between these sessions of visual exposure, the kittens were returned to the dark. After 42 days of 3 hour sessions, the effects of active versus passive movement became strikingly apparent when the kittens were tested on a visual cliff surface. The kittens who had been active in the carousel shied away from the cliff and appropriately stretched out their legs to land on the lower surface. The passive kittens showed none of that behaviour, thereby providing support for the view that the development of perception is action-dependent. Observations in humans have led to similar conclusions. For instance, Verkuyl[11] indicated that so-called Soften on children, who do not possess upper extremities due to the use of a sleeping drug in the early stages of the mother's pregnancy, had severe problems in 3D-perception.

Studies of adaptation to prismatic displacements provide further support for the importance of establishing reliable sensorimotor correlation maps through actively negotiating the physical environment. Held & Hein[12] studied prismatic displacements in humans under three conditions: active arm movement, passive arm movement, and no arm movement. In the active arm movement condition the subject swung her arm back and forth in the frontal plane, in the passive condition it was transported in the same manner by means of a moving cradle to which it was strapped. Results, as measured in terms of visual-motor negative after-effects, showed that adaptation was only produced in the active movement condition and not in the passive or no-movement conditions. Another classic experiment on visual displacement[13] used lenses that turn the world upside-down. The study showed that full adaptation to this situation (i.e., seeing the world right side up again) occurred after a few days only when subjects were allowed to actively explore a complex world. When a subject was simply pushed around in a wheelchair, he did not show this perceptual adaptation to the lenses.

Similarly, telemanipulation experiments using the Delft Virtual Window System[14] demonstrated a significant perceptual advantage of active observers, whose head movements controlled the movements of a remote camera (generating movement parallax), over passive observers, who received identical visual input (i.e. motion parallax), yet without the ability to actively change the viewpoint. This is in line with results found in relation to virtual environments, where Welch et al.[15] showed that participants who had active control over a simulated environment indicated higher levels of presence than participants who were passively exposed to the same environment.

BRAIN PLASTICITY AND OUR NEGOTIABLE BODY-IMAGE

The fact that technology can start working as a transparent extension of our own bodies is critically dependent on the highly plastic nature of our brain, which is continuously able and prone to adapt to altered sensorimotor contingencies, as the studies on adaptation to prismatic displacement and tele-systems already illustrated. This fact finds its basis in the significant evolutionary benefit of having a negotiable body image to accommodate lifetime development and change, which requires a continuous remapping of bodily boundaries. Although body-image adaptations across the lifespan can afford to take their time, it is the relative speed of these sensorimotor adaptations that enables us to experience man-made technology as, quite literally, part of ourselves - be they a blind person's cane or an advanced telerobotic arm.

Further evidence of the high-speed plasticity of the body image is provided by the amazing adaptation processes that may occur in the body-image of people with an amputated limb. Ramachandran, Rogers-Ramachandran and Cobb[16] had (amputated) phantom limb patients view their intact arm in a mirror, such that their amputated arm appeared to be resurrected. Several subjects reported feeling their phantom limb touched when they viewed the mirror image of their intact arm being touched – see also Ramachandran & Blakeslee.[17]

Botvinick and Cohen[18] provided a first description of the 'rubber hand illusion'. This crossmodal perceptual illusion occurred when participants' left hand was placed out of view and a life-size rubber model was placed in front of them. Subsequently, both the rubber hand and

participants' left hand were gently stroked by two small paintbrushes, synchronizing timing as closely as possible. In line with the Ramachandran et al.[16] results, subjects reported feeling a sense of ownership of the rubber hand, as if it was actually their own. Ramachandran, Hirstein and Rogers-Ramachandran[19] further extended this work, showing that this illusion also works when physical similarity is absent. Instead of using a rubber hand, they simply stroked and tapped the tabletop for about a minute. In this case, subjects also reported sensations arising from the tabletop. They argue that the illusion mainly arises "from the 'Bayesian logic' of all perception; the brain's remarkable ability to detect statistical correlations in sensory inputs in constructing useful perceptual representations of the world – including one's body."(p. 1500). In a further study, Armel and Ramachandran[20] showed that when the physical integrity of the rubber hand was threatened (bending a finger backwards to seem painful), a clear skin conductance response was generated, and that the illusion could even be projected to anatomically impossible locations. Using the rubber hand illusion, Ehrsson, Spence, and Passingham[21] have recently studied the neuronal counterparts of the feeling of body ownership. On fMRI measures of brain activity, they found that areas in the premotor cortex reflected the feeling of ownership of the rubber hand, indicating that the multisensory integration in this region provides a mechanism for bodily self-attribution.

The results on perceptual adaptation described in the previous paragraph, as well as the rubber hand illusion, both seem to suggest that what matters most is a closely and continuously correlated loop of sensory input, neural commands, and motor action. Thus, modality-specific feature maps appear to project onto one another through re-entrant connections, which allows disjunctive feature characteristics (e.g., visual and haptic properties of a stimulus) to be connected in the responses of higher-order networks. Sensorimotor correlations will initially be driven by the temporally ongoing parallel signalling between primary cortical areas receiving the sense data associated with stimulus objects at a given time and place. Next, stable feature correlations establish reciprocal connections between previously disjunct feature maps, thus allowing for higher order perception and categorisation of objects and environments.[22] The ensuing body image is most usefully conceptualised as a temporary construct which is remarkably flexible, and may include non-biological artefacts as an integral part of it.

FROM FAR TO NEAR: REMAPPING SPACE IN TELEPRESENCE

In general, the space that surrounds the user can be meaningfully segmented into a number of ranges, usually three or four, based on principles of human perception and action. Several models have been proposed,[23,24] all of which distinguish between a *peripersonal space* (the immediate behavioural space surrounding the person) and a far or *extrapersonal space.* Referring to haptic space, the peripersonal space corresponds to what Lederman, Klatzky, Collins & Wardell refer to as the manipulatory space, i.e., within hand's reach, whereas the extrapersonal realm would be regarded as ambulatory space, requiring exploration by movements of the body, or through the use of a tool which extends the bodily reach. Animal and human brain studies have confirmed this distinction between peripersonal and extrapersonal space, showing that space is not homogeneously represented in the brain.[25,26]

Telepresence technologies can be viewed as attempts to overcome the boundaries of spatial segmentation. Their success in doing so is evidenced by a clinical case, described by Berti and Frassinetti,[27] where a patient (P.P.), after a right hemisphere stroke, showed a dissociation between near and far spaces in the manifestation of severe visuo-spatial neglect. Using a line bisection task, the neglect was apparent in near space, but not in far space when bisection in the far space was performed with a projection light pen. However, neglect appeared in the far space as well when the line bisection task was performed with a stick (used by the patient to reach the line) and it was as severe as neglect in the near space. Thus, this study provides evidence that an artificial extension of a person's body (the stick) causes a remapping of far space as near space – *essentially telepresence.*

CONCLUSION

The same sensorimotor and brain systems responsible for our sense of bodily boundaries and

our sense of spatial location are also remarkably adaptable to include non-biological elements within the perceptual-motor loop, provided reliable, real-time sensorimotor correlations can be established. When we interact with virtual or remote environments using intuitive interaction devices, isomorphic to our sensorimotor abilities, the real-time, reliable and persistent chain of user action and system feedback will effectively integrate the technology as a phenomenal extension of the self. This fluid integration of technology into the perceptual-motor loop eventually may blur the boundary between our 'unmediated' self and the 'mediating' technology.

Naive definitions of 'self' as everything contained within our bodily boundaries, and 'non-self' as the world outside our own bodies become much less obvious when we regard the intimate dependencies and co-adaptation we can experience when technology starts working as a transparent extension of our own bodies and minds. As cognitive scientist Andy Clark convincingly argues in his wonderful book '*Natural Born Cyborgs*' , what 'I' am is not defined by the outer limits of the 'biological skin-bag'. He states: "For our sense of self, of what we know and of who and what we are, is surprisingly plastic and reflects not some rigid preset biological boundary so much as our ongoing experience of thinking, reasoning, and acting within whatever potent web of technology and cognitive scaffolding we happen currently to inhabit" (p.45).[28] Thus we learn that our relationship with technology is a two-way adaptive process - we adapt the technologies to fit our needs and abilities (a process also known as *user-centred design*), but at the same time, our brain adapts itself to the technology, so that the technology becomes part of our extended self – the biological self and all non-biological tools and toys we employ to enhance our performance and pleasure.

REFERENCES

1. Loomis, J. (1992). Distal attribution and presence. *Presence: Teleoperators & Virtual Environments 1*, 113-119.

2. Lombard, M., & Ditton, T.B. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication 3(2).* [Online: http://www.ascusc.org/jcmc/vol3/ issue2/ lombard.html]

3. Sheridan, T. B. (1992). Musings on telepresence and virtual presence. *Presence: Teleoperators and Virtual Environments 1*, 120-126.

4. Steuer, J. (1992). Defining virtual reality: Dimensions determining telepresence. *Journal of Communication 42(4)*, 73-93.

5. Slater, M. (2003). A note on presence terminology. *Presence-Connect 3*, January 2003.

6. IJsselsteijn, W.A. & de Kort, Y.A.W. (in preparation). Rethinking realism: A tale of two paradoxes.

7. Heeter, C. (1992). Being There: The Subjective Experience of Presence. *Presence: Teleoperators and Virtual Environments 1*, 262-271.

8. Ellis, S. (1996). Presence of mind: A reaction to Thomas Sheridan's 'Further musings on the psychophysics of presence'. *Presence: Teleoperators and Virtual Environments 5*, 247-259.

9. IJsselsteijn, W.A. (2004). *Presence in Depth.* Eindhoven University of Technology

10. Held, R. (1965). Plasticity in sensory-motor systems. *Scientific American 213*, 84-94.

11. Stassen, H. & Smets, G. (1995). Telemanipulation and telepresence. In: T. Sheridan (ed.) *Analysis, Design and Evaluation of Man-Machine Systems.* Amsterdam: Elsevier Science, pp 13-23.

12. Held, R., & Hein, A. (1958). Adaptation to disarranged hand-eye coordination contingent upon reafferent stimulation. *Perceptual and Motor Skills 8*, 87-90.

13. Hein, A. (1980). The development of visually-guided behavior. In: C. Harris (ed.) *Visual Coding and Adaptability.* Lawrence Erlbaum.

14. Smets, J., Overbeeke, C., & Stratmann, H. (1987). Depth on a flat screen. *Perceptual and Motor Skills 64*, 1023-1034.

15. Welch, R., Blackmon, T., Liu, A., Mellers, B., & Stark, L. (1996). The effects of pictorial realism, delay of visual feedback, and observer interactivity on the subjective sense of presence. *Presence: Teleoperators and Virtual Environments 5*, 263-273.

16. Ramachandran, V.S., Rogers-Ramachandran, D., & Cobb, S. (1995). Touching the phantom limb. *Nature 377*, 489-490.

17. Ramachandran, V.S. & Blakeslee,

S. (1998). *Phantoms in the Brain.* New York: Harper Collins.

18. Botvinick, M. & Cohen, J. (1998). Rubber hands 'feel' touch that eyes see. *Nature 391*, 756.

19. Ramachandran, V.S., Hirstein, W., & Rogers-Ramachandran, D. (1998). Phantom limbs, body image, and neural plasticity. *Int. Brain. Res. Org. News 26* (1), 10-11.

20. Armel, K.C. & Ramachandran, V.S. (2003). Projecting sensations to external objects: Evidence from skin conductance response. *Proceedings of the Royal Society of London B 270*, 1499-1506.

21. Ehrsson, H.H., Spence, C., & Passingham, R.E. (2004). That's my hand! Activity in the premotor cortex reflects feeling of ownership of a limb. *Science 305*, 875-877.

22. Edelman, G. (1987). *Neural Darwinism: The Theory of Neuronal Group Selection.* New York: Basic Books.

23. Grusser, O.-J. (1983). Multimodal structure of the extrapersonal space. In: Hein, A. & Jeannerod, M. (eds.), *Spatially Oriented Behavior.* New York: Springer-Verlag, 327-352.

24. Rizzolatti, G. & Camarda, R. (1987). Neural circuits for spatial attention and unilateral neglect. In: Jeannerod, M. (ed.), *Neurophysiological and Neuropsychological Aspects of Spatial Neglect.* Amsterdam: Elsevier Science, pp. 289-313.

25. Rizzolatti, G., Fadiga, L., Fogassi, L. & Gallese, V. (1997). The space around us. *Science 277*, 190-191.

26. Previc, F.H.. (1998). The neuropsychology of 3-D space. *Psychological Bulletin 124*, 123-164.

27. Berti, A. & Frassinetti, F. (2000). When far becomes near: Remapping of space by tool use. *Journal of Cognitive Neuroscience 12*, 1215-420.

28. Clark, A. (2003). *Natural Born Cyborgs. Minds, Technologies, and the Future of Human Intelligence.* Oxford: Oxford University Press.

Contact

Wijnand IJsselsteijn, Ph.D.
Human-Technology Interaction Group
Department of Technology Management
Eindhoven University of Technology
Eindhoven, The Netherlands
Phone: +31 40 2474455
Fax: +31 40 2449875
Email: W.A.IJsselsteijn@tue.nl

Virtual Reality in Everyday Memory Assessment and Rehabilitation: Progress to Date and Future Potential

P.R.Penn, F.D.Rose, B.M. Brooks

School of Psychology, University of East London

Abstract: *Memory impairments are one of the most disabling consequences of brain injury. They can be problematical to assess and rehabilitate, as conventional "paper and pencil" neuropsychological assessments and rehabilitation strategies are often criticised as lacking in relevance to the use of memory in the real world i.e., "ecological validity." Conventional neuropsychological memory assessments and rehabilitation strategies also often fail to cover important aspects of 'everyday memory,' such as prospective memory (remembering to perform actions in the future) and incidental memory (the encoding and recall of information without any instructions from a third party). Unfortunately, it can be very difficult to achieve the ecological validity necessary to assess everyday memory without compromising experimental control. Similarly, it is often difficult to devise rehabilitation strategies that involve real life scenarios owing to practical constraints. Virtual reality (VR) provides an elegant solution to these problems and is, therefore, an ideal tool with which to study everyday memory. This paper briefly summarises the current state of research on the applications of VR to everyday memory assessment and rehabilitation, with reference to some seminal VR work within the domains of spatial, incidental and prospective memory. Some directions for future research are suggested, and issues associated with turning empirical findings into real benefits for patients considered.*

INTRODUCTION

Over the last decade, the potential of virtual reality (VR) has, at last, begun to be realised. In the early to mid-nineties, the aspirations for the technology far exceeded its capacity to deliver on its potentiall.[1] However, massive advances in the sophistication of the hardware that underpins VR and significant reductions in the cost of such hardware have taken VR "out of the realm of expensive toy and into that of functional technology" (p3).[2]

The incorporation of VR into neuropsychological assessment and rehabilitation has possibly attracted the greatest expansion of interest from researchers in recent times. Many authors have argued that the assets of VR are especially well suited to this field.[3-5] VR has been applied to a number of domains of cognitive assessment and rehabilitation, such as: executive functioning;[6] attention ;[7] and spatial transformation.[8] However, as Brooks et al.[9] point out, the application of VR to memory impairments has been of particular interest, as memory disorders are one of the most disabling consequences of brain damage.[10] Therefore, establishing whether a patient has memory impairments is a crucial aspect of cognitive assessment and addressing any such impairment, a crucial aspect of cognitive rehabilitation.

1.1. Reconciling ecological validity and reliability: VR and everyday memory.

There are numerous "paper and pencil" neuropsychological tests of memory, e.g. the Wechsler Memory Scale - Revised,[11] the Adult Memory and Information Processing test,[12] the Recognition Memory Test,[13] and the Doors and People Test.[14] However, conventional neuropsychological tests have been heavily criticized as lacking "ecological validity" or, put another way, relevance to memory under conditions other than the laboratory/rehabilitation ward.[15] Indeed, it was the poor correlations between laboratory tests and 'everyday memory' assessments found by Sunderland, Harris and Baddeley[16] that prompted the development of the Rivermead Behavioural Memory Test (RBMT), which is designed to assess everyday memory. However, it has been argued that the

cost of introducing ecological validity into conventional neuropsychological assessment has been a loss of strict control over the test situation.[17]

The problem of balancing the demands of ecological validity with sufficiently rigorous control is also apparent in rehabilitation. Doubts have been raised as to whether rehabilitation strategies that lack ecological validity will transfer to the real world[18] and whether training behaviours in the absence of any change in the environment, or task demands, fosters sufficient intellectual flexibility and creativity to be useful in everyday life.[19] Therefore, of all the assets of VR for assessment and rehabilitation (see Rizzo, Schultheis, Kerns and Mateer,[3] for a comprehensive review) it is perhaps VR's capacity to generate environments that are satisfying from an ecological standpoint, without compromising on experimenter/therapist control, that is most exciting for memory assessment and rehabilitation research. This capacity brings with it exciting opportunities to study everyday memory phenomena. Indeed, applications of VR to memory research to date have predominantly focused on three domains of everyday memory, which have proved particularly problematical for conventional assessment and rehabilitation: i.e., spatial memory, incidental memory and prospective memory. The following provides an illustration of how the assets of VR have contributed to our understanding of the above domains of everyday memory, with reference to some significant VR research.

VR AND SPATIAL MEMORY

A good deal of the developing literature on everyday memory assessment and rehabilitation in VR to date has been directed at spatial memory, arguably for two reasons. Firstly, as Brooks et al.[9] state, adequate spatial memory is a prerequisite for independent living. Secondly, VR spatial memory tasks are particularly amenable to being orientated to utilise users' procedural memory for motor tasks e.g., simulated navigation between waypoints. This has significant implications for the reorganisation of memory function in individuals who have suffered brain damage, which will be elaborated on below.

One of the primary assets of VR in everyday memory assessment is the capacity to perform experiments that, though methodologically desirable, would not be practical in the real world. This is particularly true for research into spatial memory. A good example would be the VR adaptation of the Morris Water Task, an experimental paradigm that had proved highly informative in investigating spatial ability in rodents, to research into human spatial ability. The task involves finding a platform, which is submerged in water, purely by using memory of its position relative to external environmental cues. A desktop VR variant of this paradigm has proved useful in assessing spatial learning decrements in TBI patients, which corresponded to self- reported frequency of place learning problems in everyday life.[20]

Using the control and ecological validity afforded by VR together with fMRI generates unique and exciting insights into the neurological correlates of everyday memory, which would not be possible in the real world owing to portability issues inherent in fMRI equipment. For example, Morris et al.[21] and Paslow et al.[22] used a PC-based virtual reality set up in conjunction with fMRI in order to examine the brain correlates of egocentric memory (spatial knowledge relative to the observer) and allocentric memory (spatial knowledge relative to cues independent of the observer) in patients with anoxic hippocampal damage and normal controls. The results from these studies provided an in vivo demonstration of how anoxic brain damage can affect hippocampal function.

In addition to overcoming practical difficulties with implementing a desired methodology or permitting the incorporation of relatively inaccessible medical technology, a brief look at the use of VR in the rehabilitation of spatial memory reveals that it can also directly facilitate the reorganisation of memory ability. Research has shown that procedural memory for motor tasks can often remain relatively intact, even in individuals who exhibit profound impairments in other aspects of memory- as in the widely reported case of HM.[23] Research has also indicated that one can utilize intact procedural memory to aid or replace damaged memory systems.[24-26] Unfortunately, conducting spatial navigation tasks involving more than one room, or in an environment relevant to the patient's everyday life, can be highly problematical in the real world. This problem is easily rectified within

VR, the question was: is a simulation of a motor activity sufficient to tap into spared procedural memory in an amnesic patient? Brooks et al.[28] used a desktop VR system to train an amnesic patient (MT) to independently navigate between locations within her hospital's rehabilitation unit. When the training was extended to encompass real world and VR based training of routes (matched for complexity) within the ward, it transpired that MT learned the route practised in VR, but not the route practised in the real world. A number of features of the VR rehabilitation may have been responsible for this outcome. For example, MT could perform the route very quickly in VR resulting in more repetitions of the VR route than the route practised in the real unit. The rehabilitation strategy of backwards training was easier to implement in VR than in the real world. Finally, extraneous distractions were easily controlled in VR. A follow up study reported in Rose et al.[28] provides further support for the use of VR for route training in amnesic patients.

Researchers have also shown interest in VR as a means to encourage the development of spatial memory in children whose physical disabilities restrict their mobility. For example, Stanton et al;[29] Stanton et al[30] have conducted experiments featuring a VR model of a real school, which physically disabled children were asked to independently explore with a view to determining whether VR-based spatial memory training translates into improvements in performance in the real environment on which the virtual environment was modelled. Subsequent testing of the children on their spatial knowledge of the real school indicated that they performed better at pointing tasks and showed better route knowledge than undergraduate students who had not used the virtual environment. Similarly, Wilson et al.[31] conducted an experiment, which featured a virtual reality reproduction of two floors of the Astley Clarke building at the University of Leicester, UK. The children were asked to activate fire equipment and open a fire door to escape from the building in VR. Subsequent assessment involved asking the children to identify items of fire equipment that would not have been visible from their vantage points and the identification of the shortest route to the fire exit. The children outperformed a control group of undergraduate students who had not been exposed to the virtual environment. These studies highlight another advantage of using VR in everyday memory assessment; that the spatial memory of physically disabled participants can be assessed using VR in some situations where other forms of assessment might not be possible.

VR AND INCIDENTAL MEMORY

Incidental memory is, perhaps, the type of memory most relevant to everyday life as, unlike in conventional memory tests, often in day-to-day life individuals are not made explicitly aware that they will be required to remember a particular stimulus prior to having reason to recall it. This scenario is difficult to achieve in a laboratory, as an everyday environment is usually an integral part of the task. However, VR is ideally suited to conducting incidental memory assessments, as it can easily mimic real-life environments and tasks, and participants can then be incidentally tested on items encountered during their performance of the tasks. Despite this, the use of VR in incidental memory studies is still rare.

Andrews et al.[32] conducted a pioneering study of incidental memory for objects in VR. Participants examined a series of objects in one of five conditions: during interaction with a four-room virtual environment; in four static displays without any context; in the same four static displays, but where the participants were required to move a cursor over each object in turn; in four static pictures of virtual rooms; and using the same four pictures, but where the participants were required to move a cursor over each of the four objects in turn. Subsequent object recognition tests revealed that the poorest recognition performance occurred in the condition where participants encountered the objects in the virtual environment. Andrews et al. concluded that participants were being distracted by their interaction with the virtual environment and that incidental memory is particularly susceptible to distraction. However, they cautioned that the virtual interaction condition was most representative of participants' real-world memory ability.

Rose et al.[33] conducted an experiment to investigate incidental spatial and incidental object recognition memory in vascular brain injury patients and controls. This experiment involved the presentation of a four room virtual bungalow that participants were asked to search, ostensibly for a

toy car. A yoked-control design was used, in which half of each group of participants were assigned to an 'active' condition, which entailed controlling movement through the bungalow via a joystick. The other half were assigned to a 'passive' condition, which entailed watching the active participant's progress on a second monitor in an adjoining cubicle. Participants were assessed via a spatial layout recognition test, in which they were required to assemble 2-D maps of the virtual environment by choosing room shapes and the positions of entry and exit doorways from an array of possibilities. Active experience of the virtual environment was found to improve incidental spatial recognition memory of the layout of the four-room building for both patients and controls. Conversely, passive observation was found to improve controls' performance in the object recognition test, but not patients' performance. Using the same procedure Pugnetti et al.[34] and Rose et al.[35] replicated these findings with multiple sclerosis patients and people with learning disabilities, respectively. Pugnetti et al.[34] also found that the above finding with MS patients could not be accounted for via standard pencil & paper memory assessment tools. Thus, there is evidence that, in addition to providing an experimental tool more amenable to the study of incidental memory per se, VR may also provide a more sensitive test of incidental memory, particularly in impaired populations.

VR AND PROSPECTIVE MEMORY

Impaired prospective memory is a particularly disabling form of memory impairment, and potentially the most hazardous, as often in everyday life actions that one needs to remember to perform at some point in the future are inherently important, e.g. remembering to attend a meeting, or turn off the cooker. Consequently, the need for a comprehensive assessment of prospective memory as part of a cognitive rehabilitation programme is self-evident. However, performing an ecologically valid, yet rigorously controlled assessment of prospective memory ability in a rehabilitation setting is problematical. Kvavilashvili and Ellis[36] classified prospective memory according to the type of cue the particular task to be remembered entailed, i.e. event-based tasks (an action is required to be performed in response to a cue); time-based tasks (an action is required at a previously specified future time); or activity-based tasks (an action is required before or after performing an activity).

Based on this classification, Brooks et al.[9] devised and conducted a desktop VR prospective memory test on patients from a stroke rehabilitation unit and age-matched controls. The virtual environment used in the test was a four-room bungalow. The test involved participants performing a furniture removal task, in which they were required to instruct the experimenter to move furniture and items from the virtual bungalow to the appropriate room (out of a possible eight) of a new house, one piece at a time. This constituted the background task. Before performing this task, they were asked to remember to instruct the experimenter to put "Fragile" notices on five glass items (the event-based prospective memory task); to keep the kitchen door closed to keep the cat in (the activity-based prospective memory task); and to return to a clock in the hall at five-minute intervals and press a button, supposedly to let removal men in (the time-based prospective memory task). It transpired that 14 of the 36 stroke patients and 2 of the 22 control participants were unable to recall all three of the prospective memory task instructions immediately after they had finished the furniture removal task, even though they had been able to recall them immediately prior to beginning the task. A comparison of the results of the remaining stroke patients and controls, who were able to recall all three prospective memory tasks, indicated that the stroke patients were severely impaired relative to controls at the event and activity based tasks, but only marginally impaired at the time-based task. These results were surprising as, based on Craik's[37] theory of age-related decrements in memory, which proposes that self-initiated processing becomes more difficult for the elderly, it was envisaged that impairments in stroke patients would be more apparent in time-based tasks (which involve self-initiated retrieval) than in event or activity-based tasks (which feature external cues). If, as these results of this study indicate, self-initiated retrieval does not become much more difficult for stroke patients, their failure to remember to perform tasks in the future in this study may be attributable to a different impairment, perhaps an inability to multi-task.

Brooks et al's.[9] exploratory study indicates that VR can provide a more comprehensive and controlled assessment of prospective memory ability

than would be possible using standard memory assessment. This contributes to our understanding of the neuropsychological consequences of stroke. It also enables rehabilitation to be more effectively directed towards the specific impairments of individual patients.

DIRECTIONS FOR FUTURE RESEARCH AND ISSUES ASSOCIATED WITH TURNING VR'S POTENTIAL INTO BENEFITS FOR PATIENTS

The literature on VR and spatial memory provides a glimpse of the exciting potential of using VR in conjunction with fMRI in order to examine the neurological correlates of different forms of everyday memory.[22] Future studies could utilize this procedure to elucidate the relationship between the area of the brain affected by stroke, traumatic brain injury (TBI), or dementia and impaired everyday memory ability. Quite apart from being theoretically significant, such data would permit therapists to more accurately predict and rehabilitate the particular memory impairments that a patient would be likely to experience on the basis of their fMRI scan.

VR has demonstrated utility in assisting people with memory impairments by utilizing intact procedural memory[29] this learning has translated to improved performance in the real world. However, it is probably true to say that spatial memory tasks are particularly amenable to being broken down into a series of steps that tap into procedural memory.[9] The task of researchers and therapists is now to ascertain whether this use of VR can be successfully applied to other everyday tasks, and whether it can be used to negate some of the other disorientation, disorganization and repetition disabilities which result from different forms of memory impairment. Researchers will also have to be creative in providing ways of overcoming the lack of conscious awareness of learned knowledge common in patients with amnesia who have learned new motor skills.[14] Brooks et al also identified numerous reasons for the greater efficacy of VR training relative to real world training, e.g., less distraction, more frequent repetition, greater amenability of VR training to the errorless learning paradigm etc. It would be useful for the design of future memory rehabilitation strategies in VR to have some data on the relative importance of each of these assets in contributing to rehabilitation outcomes.

The implications of active vs. passive exploration of virtual environments for incidental spatial layout and object recognition are interesting and potentially very significant.[33] The impact, positive or otherwise, of active and passive exploration appears to be contingent on the stimuli and task demands. Rose et al. speculated that active exploration promoted the activation of procedural memory in the active participants, thereby enhancing their spatial memory of the layout of the virtual environment compared to the passive participants. The active participants' advantage did not extend to enhanced recall of the objects in the virtual environment because active participants did not interact with the virtual objects. However, it should be noted that the degree of interaction afforded by VR in memory assessment and rehabilitation is something of a double-edged sword. Increased interaction can have a deleterious effect on memory assessment and rehabilitation, as amnesic patients can have difficulty explicitly distinguishing between correct and incorrect responses/actions[38] and freedom to examine a virtual environment can prove as much of a distraction as an advantage.[32,39] Thus, experimenters/therapists must be careful to ensure that the range of interaction offered by a virtual environment does not detract from the purpose of the exercise by providing careful cueing or adopting error free learning approaches, such as that employed by.[29]

VR has been shown to provide a more comprehensive, ecologically valid, and controlled assessment of prospective memory ability than is currently possible using standard memory assessment tests. However, some questions remain from Brooks et al.[9] Firstly, it is not entirely clear whether the lack of impairment in the time-based prospective memory task in stroke patients relative to controls may have been an artifact of the interval between each retrieval occasion being too short. Thus, this aspect of the results may have been due to the time-based task not being sufficiently representative of an everyday time-based prospective memory task, as opposed to a genuine reflection on preserved prospective memory capacity. Further research, utilizing different time intervals in the time-based task, is planned to investigate this effect.

Brooks et al. also revealed that motivation is important in prospective memory performance, es-

pecially for stroke patients. During this study, participants were also given two real world based prospective memory tasks i.e. remember to ask the experimenter to return a personal belonging at the end of the study, and ask for a written explanation of the study. Results indicated that participants were significantly more likely to remember the former task, probably because they were more motivated to ask for the return of their property than for the written explanation. If rehabilitation strategies can encourage stroke patients to be more motivated to remember, it seems logical and reasonable to assume that their prospective memory abilities would improve. VR is particularly well suited to improving motivation in rehabilitation by, for example, introducing gaming elements into rehabilitation strategies.[40] Research is currently underway to determine whether manipulation of the salience of the different types of prospective memory tasks (e.g., time, event and activity based) can influence patients' capacity to remember to perform them. This may be particularly useful for the patients (and controls) in Brooks et al. who were unable even to remember what the prospective memory tasks were.

CONCLUSION

The work conducted to date clearly indicates that VR has very significant potential in the assessment and rehabilitation of everyday memory in individuals that have suffered brain injury. Further work is needed to establish whether VR can be used in the reorganization of everyday memory tasks other than simple navigation.[28] Research is also needed to further elucidate the implications of active vs. passive exploration of virtual environments and the relative contribution of the other assets of VR to everyday memory assessment and rehabilitation scenarios. Additional work involving VR used in conjunction with fMRI is clearly warranted to provide new and exciting insights into the neurological correlates of everyday memory and gain a greater understanding of how damage to different regions of the brain impacts upon everyday memory performance.

REFERENCES

1. Durlach, N.I., and Mavor, A (1995). *Virtual Reality: Scientific and Technological Challenges*, Durlach, N.I., and Mavor, A. (Eds), Washington D.C.: National Academy of Science Press.

2. Schultheis, M.T., Himelstein, J., & Rizzo, A.A. (2002) Virtual reality and neuropsychology: Upgrading the current tools. *Journal of Head Trauma Rehabilitation*, 17:5, 379-394.

3. Rizzo, A., Schultheis, M., Kerns, K., & Mateer, C. (2004). Analysis of Assets for Virtual Reality Applications in Neuropsychology. *Neuropsychological Rehabilitation*.14 (1/2), 207-239.

4. Rizzo, A., Buckwalter, J.G., & van der Zaag, C (2002), Virtual environment applications in clinical neuropsychology. In *The Handbook of Virtual Environments*, (Stanney, K Ed.), Erlbaum Publishing, New York, 1027-1064

5. Rose, F.D., Brooks, B.M. & Rizzo, A. (2004) Virtual Reality in Brain Damage Rehabilitation. CyberPsychology and Behaviour. (In press).

6. Elkind, J.S., Rubin, E., Rosenthal, S., Skoff, B. & Prather, P. (2001) A simulated reality scenario compared with the computerized Winconsin Card Sorting test: An analysis of preliminary results. *CyberPsychology and Behaviour*, 4, 489-496.

7. Rizzo, A., Pryor, L., Matheis, R., Schultheis, M., Ghahremani, K., & Sey, A. (2004) Memory assessment using graphics-based and panoramic video virtual environments. *Proc, 5th International Conf. on Disability, Virtual Reality and Associated Technologies*, in Sharkey, McCrindle & Brown (Eds.) 331-338. Oxford, UK, 20-22 Sept, 2004.

8. Rizzo, A. A., Buckwalter, J. G., Neumann, U., Kesselman, C., Thiebaux, M., Larson, P., & van Rooyan, A. (1998b). The virtual reality mental rotation/spatial skills project: Preliminary findings. *CyberPsychology and Behavior*, 1(2), 107-113.

9. Brooks, B.M., Rose, F.D., Potter, J., Attree, E.A., Jayawardena, S., & Morling, A. (2002) Assessing stroke patients' ability to remember to perform actions in the future using virtual reality, *Proceedings of the 4th International Conference on Disability, Virtual Reality and Associated Technologies*, Hungary, 239-245.

10. Schacter, D.L., Glisky, E.L., & McGlynn, S.M. (1990) Impact of memory disorders on everyday life: awareness of deficits and return to work, in: *The Neuropsychology of Everyday Life: Assessment and Basic Competencies*, D.E. Tupper and K.D. Cicerone, eds., Kluwer Academic Publishers, Massachusetts, 1990, 231-257.

11. Wechsler, D. *Wechsler Memory Scale - Revised.* Psychological Corporation, San Antonio, 1987.
12. Coughlan, A.K & Hollows, S.E. *The Adult Memory and Information Processing Battery,* A.K. Coughlan, St. James's Hospital, Leeds, 1985.
13. Warrington, E.K. Recognition Memory Test, NFER-Nelson, Windsor, (1984).
Baddeley, A., Emslie, H., & Nimmo-Smith, I. *The Doors and People Test,* Thames Valley Test Co., Bury St Edmunds, Suffolk, 1994.
14. Baddeley, A.D. (1990) *Human Memory: Theory and Practice,* Psychology Press, Hove, UK, 1990.
15. Neisser, U. (1978) Memory: What are the important questions? in: *Practical Aspects of Memory,* Gruneberg, M. M., Morris, P.E. and Sykes, R.N. eds., Academic Press, London, 1978, 3-24.
16. Sunderland, A., Harris, J.E., & Baddeley, A.D. (1983) Do laboratory tests predict everyday memory? Journal of Verbal Learning and Verbal Behavior, 22, 341-357.
17. Banaji, M.R., & Crowder, R.G. (1989) The bankruptcy of everyday memory, *American Psychologist,* 44, 1185-1193.
18. O'Conner, M., & Cermack, L. S. (1987). Rehabilitation of organic memory disorders. In M. J. Meier, A. L. Benton, & L. Diller (Eds.) *Neuropsychological rehabilitation.* New York: Guilford.
19. Kirsch, N.L., Levine, S. P. Lajiness-O'neill, R., & Schnyder, M. (1992). Computer-assisted interactive task guidance: Facilitating the performance of a simulated vocational task. *Journal of Head Trauma Rehabilitation,* 7 (3), 13-25.
20. Skelton, R.W., Bukach, C.M., Laurance, H.E., Thomas, K.G., Jacobs, J.W. (2000) Humans with traumatic brain injuries show place-learning deficits in computer-generated virtual space. *Journal of Clinical Experimental Neuropsychology,* 22, 157–75.
21. Morris, R.G., Parslow, D., Fleminger, S., Brooks, B., Brammer, M. & Rose, D. (2002) Functional magnetic resonance imagining investigation of allocentric spatial memory tested using virtual reality in patients with anoxic hippocampal damage, *Proceedings of the 4th International Conference on Disability, Virtual Reality and Associated Technologies,* Hungary, 87-92
22. Parslow, D.M., Rose, F.D., Brooks, B.M., Fleminger, S., Gray, J.A., Giampietro, V., Brammer, M.J., Williams, S.C.R. Gasston, D. Andrew, C., Goparlen, N., Vythelingum, N., Loannou, G., Sirnmons, A., & Morris, R.G. (2004). Allocentric spatial memory activation of the hippocampal formation measured using fMRI. *Neuropsychology.* 18 (3) 450-461
23. Milner, B., Corkin, S. & Treuber, H.L. (1968), Further analysis of the hippocampal amnesic syndrome: 14-year follow-up of HM, *Neuropsychologia,* 6, 215-234.
24. Glisky, E.L. (1995) Acquisition and transfer of word processing skill by an amnesic patient, *Neuropsychological Rehabilitation,* 5, 299-318.
25. Glisky, E.L., and Schacter, D.L. (1988) Long-term retention of computer learning by patients with memory disorders, *Neuropsychologia,* 26, 173-178.
26. Glisky, E.L., & Schacter, D.L. (1986) Learning and retention of computer-related vocabulary in amnesic patients: Method of vanishing cues, *Journal of Clinical and Experimental Neuropsychology,* 8, 292-312.
27. Brooks, B.M., McNeil, J.E., Rose, F.D., Greenwood, R.J., Attree, E.A., & Leadbetter, A.G. (1999) Route learning in a case of amnesia: A preliminary investigation into the efficacy of training in a virtual environment, *Neuropsychological Rehabilitation* 9, 63-76.
28. Rose, F.D., Attree, E.A., Brooks, B.M., & Andrews, T.K. (2001) Learning and memory in virtual environments: A role in neurorehabilitation? Questions (and occasional answers) from the University of East London, *Presence* 10, 345-358.
29. Stanton, D., Wilson, P., Duffy, H., and Foreman, N. (2000) Virtual environments as spatial training aids for children and adults with physical disabilities. *3rd International Conference on Disability, Virtual Reality and Associated Technologies.* Sardinia, 23rd-25th September.
30. Stanton, D, Foreman, N., Wilson, P., Duffy, H. & Parnell, R. (2002) Use of virtual environments to acquire spatial understanding of real-world multi-level environments. *Proceedings of the 4th International Conference on Disability, Virtual Reality and Associated technologies, Hungary, 2002,* 13-18
31. Wilson, B.A. and Evans, J.J. (1996) Error-free learning in the rehabilitation of people with memory impairments, *Journal of Head Trauma Rehabilitation,* 11, 54-64.
32. Andrews, T.K., Rose, F.D., Leadbetter, A.G., Attree, E.A. & Painter, J. (1995) The use of virtual reality in the assessment of cognitive

ability. in: *Proceedings of the 2nd TIDE Congress*, I. Placencia Porrero and R. Puig de la Bellacasa, eds., IOS Press, Amsterdam, 1995, 276-279.
33. Rose, F.D., Brooks, B.M., Attree, E.A., Parslow, D.M., Leadbetter, A.G., McNeil, J.E., Jayawardena, S., Greenwood, R. & Potter, J. (1999) A preliminary investigation into the use of virtual environments in memory retraining after vascular brain injury: Indications for future strategy? *Disability and Rehabilitation,* 21, 548-554.
34. Pugnetti, L., Mendozzi, L., Brooks, B.M., Attree, E.A., Barbieri, E., Alpini, D., Motta, A., & Rose, F.D. (1998) Active versus passive exploration of virtual environments modulates spatial memory in MS patients: a yoked control study. *The Italian Journal of Neurological Sciences* 19, 424-430.
35. Rose, F.D., Brooks, B.M., & Attree, E.A. (2002) An exploratory investigation into the usability and usefulness of training people with learning disabilities in a virtual environment, *Disability and Rehabilitation,* 24, 627-633.
36. Kvavilashvili, L., & Ellis, J. Varieties of intention: Some distinctions and classifications (1996) in: *Prospective Memory: Theory and Applications*, Brandimonte, M., Einstein, G.O. and McDaniel, M.A. eds., Lawrence Erlbaum, New Jersey, 23-51.
37. Craik, F.I.M. (1986) A functional account of age differences in memory, in: *Human Memory and Cognitive Capabilities*, Mechanisms and Performances, Klix, F. and Hagendorf, H. eds., Elsevier, Amsterdam, 1986, 409-422.
38. Wilson, P.N., Foreman, N. & Tlauka, M. Transfer of spatial information from a virtual to a real environment in physically disabled children. (1996) *Disability and Rehabilitation* 18, 633-637.
39. Rizzo, A., Klimchuk, D., Mitura, R., Bowerly, T., Shahabi, C., & Buckwalter, J.G. (2004). Diagnosing Attention Disorders in a Virtual Classroom. *IEEE Computer.* 37 (5), 87-89.
40. Deutsch, J., Latonio, J., Burdea, G., & Boian, R. (2001) Rehabilitation of Musculoskeletal Injuries Using the Rutgers Ankle Haptic Interface: Three Case Reports, *Eurohaptics Conference*, Birmingham UK, July 1-4, 2001

Contact

Paul Penn PhD
School of Psychology.
University of East London. UK.
Telephone: +44(0) 208 223 [4424|4425|4500]
E-mail: P.R.Penn@uel.ac.uk

Virtual Reality in the Treatment of Eating Disorders and Obesity: State of the Art and Future Challenges

G. Riva, Ph.D.

ATN-P Lab., Istituto Auxologico Italiano, Milan, Italy

Abstract: *Virtual Reality (VR) is an advanced human-computer interface that allows the user to interact with and become immersed in a computer-generated environment in a naturalistic fashion.*

Different clinical data suggest that VR can help in addressing two key features of eating disorders and obesity not always adequately addressed by existing approaches: body experience disturbances and self-efficacy.

In fact, performance-based methods are the most effective in producing therapeutic change across behavioral, cognitive, and affective modalities. The experiential approach allowed by VR helps patients in discovering that difficulties can be defeated, so improving their cognitive and behavioral skills for coping with stressful situations. On the downside, the cost of this technology remains relatively high, its availability is still limited and some patients (1-2%) may experience simulation sickness.

The paper discusses the pros and cons of this approach presenting the results coming from the last controlled clinical trials.

INTRODUCTION

Different new technologies have been introduced over the last few years that are increasingly finding application in health care delivery for patients with eating disorders and obesity. These include self-help (supervised and unsupervised), telemedicine, telephone therapy, e-mail, Internet, computer software, CD-ROMs, portable computers, and virtual reality techniques.[1] One of the most promising is virtual reality (VR), an advanced form of human-computer interface that allows the user to interact with and become immersed in a computer-generated environment in a naturalistic fashion.[2]

In fact, therapists are using VR to provide a new human-computer interaction paradigm in which users are active participants within a computer-generated three-dimensional virtual world.[3] Using VR in this way, the patient is more likely not only to gain an awareness of his/her need to do something to create change but also to experience a greater sense of personal efficacy.[4]

This feature of VR has been extensively used in different clinical psychology treatments - from phobias to sexual disorders - and it is expected to increase in the future.[5,6] In particular, an area in which VR may offer a competitive advantage is the treatment of eating disorders and obesity.

Different clinical data suggest that VR can help in addressing two key features of eating disorders and obesity not always adequately addressed by existing approaches: body experience disturbances and self-efficacy.[7]

The paper discusses the pros and cons of this approach presenting the results coming from the last controlled clinical trials.

RATIONALE AND CLINICAL DATA

Distorted body image, negative emotions and lack of faith in the therapy are typical features of these disturbances and are the most difficult characteristics to change. One innovative approach to their treatment is to enhance tradi-

Hardware	Graphic Workstation with high-end graphic card
	Head Mounted Display or 3D shutter glasses
	Tracking System (Head and Hands)
	VR Gloves
Software	VR environment

Table 1: VR Components

tional cognitive-behavioral therapy (CBT) with the use of a virtual environment.[1,3,9]

A first approach is the one offered by the Integrated Experiential Therapy (IET). Developed by Giuseppe Riva and his group inside the VREPAR and VEPSY Updated European funded projects (http://www.cybertherapy.info) is a relatively short-term, patient oriented approach that focuses on individual discovery.[10-12] IET shares with CBT the use of a combination of cognitive and behavioral procedures to help the patient identify and change the maintaining mechanisms. However it is different for:

- Its use of Virtual Reality (VR): 10 VR sessions.
- Its focus on the negative emotions related to the body, a major reason patients want to lose weight.
- Its focus on supporting the empowerment process. VR has the right features to support empowerment process, since it is a special, sheltered setting where patients can start to explore and act without feeling threatened.

For the virtual reality sessions, the Virtual Reality for Eating Disorders Modification - VREDIM - is used. VREDIM is an enhanced version of the original Virtual Reality for Body Image Modification (VEBIM) immersive virtual environment, previously used in different preliminary studies on non-clinical subjects[13,14]

VREDIM is composed by 14 virtual environments, used by the therapist during a 50-minute session with the patient.[11] After a first assessment session, the next 9 sessions are used to assess and modify:

- *the symptoms of anxiety related to food exposure*. This is done by integrating different cognitive-behavioral methods (see Table 1): Countering, Alternative Interpretation, Label Shifting, Deactivating the Illness Belief and Temptation Exposure with Response Prevention.[15,16]
- *the body experience of the subject*. To reach this goal, the virtual environment integrated the therapeutic methods used by Butter & Cash[17] and Wooley & Wooley.[18] In particular in VREDIM the virtual environment is used in the same way as guided imagery[19] is used by the cognitive and visual/motorial approach. Moreover, in terms of learning theory, repeated and prolonged exposure with the conditioned stimulus "seeing one's own body" is supposed to induce decreases in the conditioned negative reactivity by preventing negative reinforcement, e.g., avoidance.[20]

The VR sessions (see Figure 1) approximate natural settings, providing an alternative for exposure and desensitization exercises as well as a more general enhancement to therapy. Specifically, VR is believed to increase motivation by allowing individuals to virtually witness changes in their behavior and shape and reach their own conclusions based on actual experience. During a typical VR sessions, patients are asked to wear a head mounted VR display system. An approach similar to guided imagery is used to lead the subject through various zones over the course of ten sessions. Stimuli that contribute to abnormal eating behaviors are identified and associated anxiety and body experiences are targeted for modification.

Subjects are also asked to identify figures that most closely resemble their current and ideal body sizes. They are also confronted with a photograph of their actual body.

This approach was validated through different case studies[21] and trials. In the first one, uncontrolled, three groups of patients were used[22]: patients with Binge Eating Disorders (BED), patients with Eating Disorders Not Otherwise Specified (EDNOS), and obese patients with a body mass index higher than 35. All patients participated in five biweekly sessions of the therapy. All the groups showed improvements in overall body satisfaction, disordered eating, and related social behaviors, although these changes were less noticeable in the EDNOS group.

More recently, the approach was tested in different controlled studies. The first one involved twenty women with BED who were seeking residential treatment.[11] The sample was assigned randomly to IET or to CBT based nutritional therapy. Both groups were prescribed a 1,200-calorie per day diet and minimal physical activity. Analyses revealed that although both groups were binge free at 1-month follow-up, IET was significantly better at increasing body satisfaction. In addition, IET participants were more likely to report increased self-efficacy and motivation to change.

In a second one, the same randomized approach was used with a sample of 36 women with BED.[12] The results showed that 77% of the ECT group quit binging after 6 months versus 56% for the CBT sample and 22% for the nutritional group sample. Moreover, the ECT sample reported better scores in most psychometric tests including EDI-2 and body image scores.
In the final one, recently presented in the Medicine Meets Virtual Reality Conference 2005, IET was compared with nutritional and cognitive-behavioral treatments, using a randomized controlled trial, in a sample of 211 female obese patients. Both IET and CBT produced a better weight loss than NT after a 6-month follow-up. However, IET was able to significantly improve, over CBT and NT, both body image satisfaction and self-efficacy. This change produced a reduction in the number of avoidance behaviors as well as an improvement in adaptive behaviors.

Figure 1: A patient is trying the Integrated Experiential Therapy

The Spanish research group led by Cristina Botella has compared the effectiveness of VR to traditional CBT for body image (based on Cash[23] and reported on a small controlled study with a clinical population.[24]

The main tool they developed is a 3D figure, experienced through an immersive headset, whose body parts (arms, thighs, legs, breasts, stomach, buttocks, etc.) that could be enlarged or diminished.[8] Further, the body could be

VR Workstation	**Indicative Prices (as 01 Jan 05)**
SGI Onyx4 visualization system with InfinitePerformance & InfiniteReality4 graphics	250000 US$
SGI Onyx 350, V12 Graphic Card, 2x400MHz processors, 512 Mbyte Ram, 18 Gbyte Hard Disk	18000 US$
Xeon branded PC, 2x3Ghz processors, 1Gbyte Ram, 2x200 Gbyte Hard Disk and 17" monitor	4200 US$
Pentium IV or Athlon XP branded PC, 3.4 Ghz processor, 512 Mbyte Ram, 200 Gbyte Hard Disk and 17" monitor	2600 US$
Consumer graphic cards	
Nvidia GeForceFX 6800 Ultra 256 Mbyte Vram PCI Express	550 US$
ATI Radeon X800 Pro All-in-Wonder 256 Mbyte PCI Express	550 US$
Professional graphic cards	
Quadro4 FX 4400 512 Mbyte Vram PCI Express	1600 US$
ATI FireGL X3-256 256 Mbyte Vram AGP	1200 US$
Tracking system	
Polhemus Fastrak	7000 US$
Ascension PC Flock of Birds	2200 US$
Intersense Intertrax 2	1100 US$
3D Shutter Glasses	
StereoEyes Wireless	320 US$
Elsa 3D Revelator IR	180 US$
Head Mounted Display	
Kaiser Proview XL 40/50 (XGA resolution – 3D, wide fov)	50000 US$
Daeyang I-Visor DH4400 VP 3D (SVGA resolution – 3D)	1900 US$
Olympus Eye-Trek FMD-700 (SVGA resolution – 2D)	1300 US$
Daeyang I-Visor DH4400 VP (SVGA resolution – 2D)	1200 US$
Sony Glasstron PLM-A35 (Video output only – 2D)	500 US$
VR Gloves	
Pinch Glove	2000 US$
5DT Right Hand	650 US$

Table 2: VR Hardware

evaluated wholly or in parts and placed in different contexts (for instance, in the kitchen, before eating, after eating, facing attractive persons, etc.).

Within the published study, five patients - 3 with Anorexia Nervosa and 2 with Bulimia Nervosa completed the traditional treatment and 8 - 4 with Anorexia Nervosa and 4 with Bulimia Nervosa - completed the VR condition.

Although both groups showed improvements on general ED measures, there were no significant between-group differences. However, the VR group did show greater improvement on measures of body image, dysphoria, and anxiety, leading the authors to conclude that VR targets disturbances in body image better than standard CBT. On a 10-point scale, patients rated the realism of VR from 7 to 9. Since then, the group has also developed a VR simulator of food and eating[25] actually under evaluation with patients.

CONCLUSIONS

In summary, the published data suggest that VR can help in addressing two key features of eating disorders and obesity not always adequately addressed by existing approaches: body experience disturbances and self-efficacy. VR technology offers an innovative approach to the treatment of body image disturbance, a difficult concept to address in therapy. Previously, cognitive-behavioral and feminist approaches have been the standard interventions, although in our experience, it seems that many patients continue to struggle with negative body image post-treatment.

As emphasized by social cognitive theory, performance-based methods are the most effective in producing therapeutic change across behavioral, cognitive, and affective modalities.[26,27] The proposed experiential approach could help patients in discovering that difficulties can be defeated, so improving their cognitive and behavioral skills for coping with stressful situations.

On the downside, a limited number of patients (less than 2%) experienced simulator sickness, which consists of nausea, disorientation, and eye strain or blurred vision during and after use. In addition, the cost of this technology remains relatively high (see Table 1) and availability is still limited: a typical VR system as the one used in the studies discussed before costs between 15000 and 25000 euro (hardware 10000-15000 euro; software: 5000-10000 euro).

Finally, communication networks have the potential to transform VEs into shared worlds in which individuals, objects, and processes interact without regard to their location. In the next five years, such networks will probably merge VR and telemedicine applications allowing us to use VR for such purposes as distance learning, distributed training, and e-therapy.

ACKNOWLEDGMENTS

The present work was partially supported by the Italian MIUR FIRB programme (Projec "*Neurotiv Managed care basata su telepresenza immersiva virtuale per l'assessment e riabilitazione in neuro-psicologia e psicologia clinica*" - RBNE01W8WH- http://www.neurotiv.org - and Project "*Realtà virtuale come strumento di valutazione e trattamento in psicologia clinica: aspetti tecnologici, ergonomici e clinici*" – RBAU014JE5).

REFERENCES

1. Myers, T. C., Swan-Kremeier, L., Wonderlich, S., Lancaster, K., & Mitchell, J. E. (2004). The use of alternative delivery systems and new technologies in the treatment of patients with eating disorders. *International Journal of Eating Disorders, 36*(2), 123-143.
2. Riva, G., Botella, C., Légeron, P., & Optale, G. (Eds.). (2004b). *Cybertherapy: Internet and virtual reality as assessment and rehabilitation tools for clinical psychology and neuroscience.* Amsterdam: IOS Press; Online: http://www.cybertherapy.info/pages/book3.htm.
3. Rizzo, A., Schultheis, M. T., Kerns, K., & Mateer, C. (2004). Analysis of assets for virtual reality applications in neuropsychology. *Neuropsychological Rehabilitation, 14*(1-2), 207-239.
4. Riva, G., & Gamberini, L. (2000). Virtual reality as telemedicine tool: Technology, ergonomics and actual applications. *Technology and Health Care, 8*(2), 113-

127.
5. Botella, C., Quero, S., Banos, R. M., Perpina, C., Garcia Palacios, A., & Riva, G. (2004). Virtual reality and psychotherapy. *Stud Health Technol Inform, 99*, 37-54.
6. Riva, G. (Ed.). (1997b). *Virtual reality in neuro-psycho-physiology: Cognitive, clinical and methodological issues in assessment and rehabilitation.* Amsterdam: IOS Press. Online: http://www.cybertherapy.info/pages/book1.htm.
7. Riva, G., Bacchetta, M., Cesa, G., Conti, S., & Molinari, E. (2004a). The use of VR in the treatment of eating disorders. *Studies in Health Technology and Informatics, 99*, 121-163.
8. Perpiña, C., Botella, C., & Baños, R. M. (2003). Virtual reality in eating disorders. *European Eating Disorders Review, 11*(3), 261-278.
9. Riva, G., Bacchetta, M., Cesa, G., Conti, S., & Molinari, E. (2002b). E-health in eating disorders: Virtual reality and telemedicine in assessment and treatment. *Stud Health Technol Inform, 85*, 402-408.
10. Riva, G., Bacchetta, M., Baruffi, M., & Molinari, E. (2001). Virtual reality-based multidimensional therapy for the treatment of body image disturbances in obesity: A controlled study. *Cyberpsychology and Behavior, 4*(4), 511-526.
11. Riva, G., Bacchetta, M., Baruffi, M., & Molinari, E. (2002a). Virtual-reality-based multidimensional therapy for the treatment of body image disturbances in binge eating disorders: A preliminary controlled study. *IEEE Transactions on Information Technology in Biomedicine,* 6(3), 224-234.
12. Riva, G., Bacchetta, M., Cesa, G., Conti, S., & Molinari, E. (2003). Six-month follow-up of in-patient experiential-cognitive therapy for binge eating disorders. *CyberPsychology & Behavior, 6*(3), 251-258.
13. Riva, G. (1997a). The virtual environment for body-image modification (vebim): Development and preliminary evaluation. *Presence, Teleoperators, and Virtual Environments, 6*(1), 106-117.
14. Riva, G. (1998a). Modifications of body image induced by virtual reality. *Perceptual and Motor Skills, 86*, 163-170.
15. Riva, G. (1998b). Virtual reality vs. Virtual body: The use of virtual environments in the treatment of body experience disturbances. *CyberPsychology & Behavior, 1*(2), 129-137.
16. Schlundt, D. G., & Johnson, W. G. (1990). *Eating disorders: Assessment and treatment.* Needham Heights, MA: Allyn and Bacon.
17. Butters, J. W., & Cash, T. F. (1987). Cognitive-behavioral treatment of women's body image satisfaction: A controlled outcome-study. *Journal of Consulting and Clinical Psychology, 55*, 889-897.
18. Wooley, S. C., & Wooley, O. W. (1985). Intensive out-patient and residential tratment for bulimia. In D. M. Garner & P. E. Garfinkel (Eds.), *Handbook of psychotherapy for anorexia and bulimia* (pp. 120-132). New York: Guilford Press.
19. Leuner, H. (1969). Guided affective imagery: A method of intensive psychotherapy. *American Journal of Psychotherapy, 23*, 4-21.
20. Hilbert, A., Tuschen-Caffier, B., & Vogele, C. (2002). Effects of prolonged and repeated body image exposure in binge-eating disorder. *Journal of Psychosomatic Research, 52*(3), 137-144.
21. Riva, G., Bacchetta, M., Baruffi, M., Rinaldi, S., & Molinari, E. (1999). Virtual reality based experiential cognitive treatment of anorexia nervosa. *Journal of Behavioral Therapy and Experimental Psychiatry, 30*(3), 221-230.
22. Riva, G., Bacchetta, M., Baruffi, M., Rinaldi, S., Vincelli, F., & Molinari, E. (2000). Virtual reality based experiential cognitive treatment of obesity and binge-eating disorders. *Clinical Psychology and Psychotherapy, 7*(3), 209-219.
23. Cash, T. F. (1996). The treatment of body image disturbances. In J. K. Thompson (Ed.), *Body image, eating disorders and obesity* (pp. 83-107). Washington, DC: APA - American Psychological Association.
24. Perpiña, C., Botella, C., Baños, R. M.,

Marco, J. H., Alcañiz, M., & Quero, S. (1999). Body image and virtual reality in eating disorders: Exposure by virtual reality is more effective than the classical body image treatment? *CyberPsychology & Behavior, 3*(2), 149-159.
25. Lozano, J. A., Alcaniz, M., Gil, J. A., Moserrat, C., Juan, M. C., Grau, V., et al. (2002). Virtual food in virtual environments for the treatment of eating disorders. *Stud Health Technol Inform, 85*, 268-273.
26. Alcañiz, M., Baños, R., Botella, C., & Rey, B. (2003). The emma project: Emotions as a determinant of presence. *PsychNology Journal, 1*(2), 141-150. On-line: http://www.psychnology.org/article204.htm.
27. Bandura, A. (1985). *Social foundation of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice-Hall.

Contact

Giuseppe Riva
Applied Technology for Neuro-Psychology Lab
Istituto Auxologico Italiano
Email: auxo.psylab@auxologico.it

Virtual Technologies for Extreme Environment Effect Mitigation

E. Gaia, Dr. Ing

Alenia Spazio S.p.A., Torino Italy

Abstract: *This paper examines the demands of a manned system operating in an extreme environment, where there is the need to enhance or at least maintain crew health, team spirit and cohesion, and how nouvelles techniques based on Virtual Reality technologies can provide some answers. A typical example is a manned mission to Mars with a crew of 4-8 astronauts where it is mandatory to maintain their psychological health for a mission that is envisaged to last from two to three years. They will have to work and live in an artificial environment with limited resources (for example communication capability with ground, due to the distances involved, cannot be a direct two way system) and living volumes. The paper proposes some possible fields of investigation. It will also consider the fact of how these innovative technologies based on Virtual Reality will have to be developed and tested.*

INTRODUCTION

In the next 25 years we can expect to see two things. First human beings will be installed in various extreme environments of which one can be the Moon or even Mars. On the other hand many new Virtual Reality (VR) applications will be available to augment our capabilities in various areas from entertainment to medicine and engineering, but it is also possible to envisage that VR or AR (Augmented Reality) may be especially employed where the human being is facing highly demanding challenges. In this paper what might be used in future manned space missions is discussed with a special emphasis on the possible utilisation of VR/AR to support the maintenance of on-board crew well-being.

IDENTIFICATION OF THE PROBLEM

The future Moon and Mars exploration missions foresee, after some pilot missions to the Moon, a series of long missions with human permanence on board. These range from permanence on the Moon surface of one year (the trip of 3-4 days to the Moon is negligible compared to the permanence) to a mission to Mars of three years of which up to one may be spent in travelling to and fro. The envisaged size of the crew ranges from 4 to 8 people, each of whom is highly motivated and knowledgeable. The crew will certainly be specifically selected and highly trained. In addition, they will receive all possible support, and it is expected that VR/AR techniques will be widely employed to provide this support, augmenting crew capability in controlling the overall system, robots and handling communications. It would not be surprising, for example, if VR/AR based training techniques were employed both on ground in preparing the mission and in orbit to handle the unexpected. But there is another area where VR/AR may be employed, that is in the maintenance of the crew's psychical well-being and in maintaining the team's positive attitude and cohesion.

TYPICAL MISSION: EXPLORATION SPIRAL 3/LUNAR BASE AND MARS TESTBED

From NASA Requirements Document "ESMD-RQ-0013". "Exploration Spiral 3 will establish the capability to conduct routine human long-duration missions at a lunar base to test out technologies and operational techniques for expanding the human presence to Mars and beyond. Missions in Spiral 3 will extend up to several months in duration at the lunar poles or equatorial region in order to serve as an operational analog of future Mars missions. Spiral 3 will require the development and deployment of habitats and surface power systems. ... Once the surface systems are in place, successively longer missions will be conducted to increase

the understanding of system technical performance (including health and human systems), and to provide increasing levels of operational autonomy capabilities that will be necessary for future human Mars exploration missions."

Related Main Mission Characteristics:

- Crew: 4 Astronauts.
- Gravity: 1/6 of the gravity of the Earth
- Mission Duration:
  - o 6 days travel from Earth to Moon;
  - o 42 to 600 days permanence on the surface;
  - o 7.5 days from Moon back to Earth.
- Habitation Facilities:
  - o Transportation phases Crew Exploration Vehicle (CEV) plus Mission Module approx. 14 m^3 volume available for the crew;
  - o Up to 200 m^3 gross volume available for the crew for habitability and working areas. This volume may be increased with an additional logistic cargo module that can be connected to the main habitation and laboratory module.
- Surface Crew working and related Activities:
  - o It is expected that in one year there will be more than 200 Extra Vehicular Sorties with two people in each one;
  - o Control the extensive utilization of robots and automated Rovers for exploration
  - o Other activities foreseen are system maintenance and performance of experiments to prepare for Mars missions.
- Surface Crew off-duty and related Activities:
  - o Housekeeping
  - o Exercise & health maintenance
  - o Eating, sleeping and hygiene

Free time.

Identified issues:

- **Communications**: although the distance between the Moon and the Earth is relatively small, communication delay is of approximately 6 seconds each leg. This will require a different concept of control for all used automated systems. Now most of the controls are performed on ground by the flight control personnel. For voice communication it might be only a nuisance but its effects on the crew over a long period are unknown. In case of Mars mission the communication delay can be up to 20 minutes each leg: this will sharply increase the communication problem.

- **Safety & Isolation**: the handling of emergencies during these exploration missions is completely innovative with respect to the approach taken for the Space Station where an injured or ill crew member can be back on the Earth in approximately 12-16 hours. Starting from the Moon surface it would take as a minimum 5-6 days and from Mars up to 6 months to return to Earth, so most of the emergencies must be handled there.

- **Group dynamics and roles of each astronaut:** this is one of the keys to mission success, which means being able to maintain - throughout the mission and despite any problem that may arise - a positive attitude of each single component of the team as well as of the team itself.

POSSIBLE ROLE OF VR

Most probably there will be quite ample applications of VR/AR techniques to improve the quality of the working environment on board during these long exploration missions. These applications can be envisaged in the field of:

- Communications between Moon base and the Earth or between the exploring astronauts and the Moon Base.
- Training (on the job)
- Automatics and Robotics command/control

- Support to procedure implementation,
Leisure i.e. movies and scenery display (some students have conceived a relaxation room with VR)

All these applications are up to now perceived as single pieces of application, each developed to handle a specific need but not linked one to the other. What has been missing up to now is an integrated system that can perform all that has been mentioned before, but beyond that will be able to take care of the maintenance of the psychological well-being of the astronauts both at individual level as well as at team level. This system shall be capable to move from present applications of VR techniques aimed at restoring people's well-being by, for example, treating the fear of flying like the VR technique described in reference[2] to a nouvelle application of monitoring and maintaining the human being's well being.

An integrated system based on VR/AR technique of exchange of information and control with the crew also with the use of nouvelle techniques of Brain Computer Interface (BCI) can be developed. This integrated system can not only give the crew an effective support both in working and non-working activities but, since it can be envisaged that it would be capable of monitoring their health, it can also intervene by taking actions to reduce/control potentially dangerous situations.

DISCUSSION

Clearly a system such as the one proposed is not available in the short term and it will take a well coordinated effort to develop; on the other hand, there are some issues - some simple but some others much more complex involving ethics - that it is better to start discussing now.
The following are the issues to be investigated in order to set the requirements capable to describe a system to be produced that respects the ethics of the human being but on the other hand is capable of guaranteeing the mission success:

- Private experiences vs. common experience (screen vs. helmet or both): How can the group dynamics be supported?
- Communication system: How to overcome the time lag constraint maintaining a level of "quality" and "effectiveness" in communication? - especially if it is used as a keystone for well-being maintenance.
- Psychological Health maintenance: How and when can VR/AR be used to support the Crew's Psychological Health?
- Psychological Health monitoring system: How can the psychological well-being of the singular member and of the group be monitored?
- Training and other VR/AR applications used for Crew support: VR/AR are recognised candidate techniques for training as well as to provide information and control capability to a crew member but can this VR/AR system be exploited to the level required without overloading the human being?
- Human VR interfaces: New interfaces are being developed including the BCI: how can these be used without violating ethical rules?

If such a system can be developed and accepted for utilisation would it be possible to refer to it as VR/AR system or must we use a new word like an enhanced reality system?

CONCLUSION

This paper was not aimed at giving solutions but more at collecting questions and doubts. Nevertheless two positive issues can be gathered from what was presented before:

- First how extreme environments can be used as technological trend identification and then can become valid test beds for research and development of new techniques
How a user centred approach is more and more needed in order not to be overcome by the technological push especially in new areas like VR/AR.

REFERENCES

[1] Exploration Crew Transportation System Requirements Document (Spiral 3) Version Preliminary – Revision D 22 Feb 2005 (ESMD-RQ-0013) - http://exploration.nasa.gov/documents/documents.html

[2] The Treatment of Fear of flying: A Controlled Study of Imaginal and Virtual Reality Graded Exposure Therapy: Brenda K. Wiederhold, et all. – IEEE Transactions on Information Technology in Biomedicine, Vol. 6, NO. 3, September 2002.

Contact

Enrico Gaia
Alenia Spazio S.p.A.
Torino, Italy
Phone: +39 011 7180742
Email: Enrico.Gaia@aleniaspazio.it

Evaluation Studies

A Computational Model of Emotion and Personality: Applications to Psychotherapy Research and Practice

E. Hudlicka, Ph.D.

Psychometrix Associates, Inc. Blacksburg, Virginia

Abstract: *VR applications in psychotherapy are gaining prominence in the research community and acceptance among practitioners, with particular successes in the area of phobia treatments. However, a promising technology remains unexplored: computational models of cognition and emotion. Cognitive models (also termed cognitive- or agent-architectures) aim to emulate cognitive processing such as attention, perception, and decision-making, and are used by cognitive scientists to advance understanding of the mechanisms and structures mediating cognition. These models are also used in applied settings to improve the realism of training and assessment environments, and to improve human-computer interaction and system design. Recently, architectures have been developed that explicitly represent emotions: both emotion appraisal processes, and effects of emotions on cognition. Such computational models of cognition and emotion have two types of applications in cybertherapy. First, they can enhance the realism of a synthetic agents used in VR assessment and treatment environments (e.g., avatars used in social phobia treatment). Second, they have the potential to advance our understanding of the etiology and treatment of a variety of affective disorders, by enabling the modeling of the mechanisms of cognitive-affective interactions that play central role in these disorders, and in their treatments. In this paper I first describe a cognitive-affective architecture capable of modeling the dynamic generation of emotions (affect appraisal), and selected effects of emotion on cognition. I then describe possible applications of this architecture to psychotherapy practice and research.*

INTRODUCTION

VR applications in psychotherapy are gaining prominence in the research community and acceptance among practitioners. Significant success has been achieved with VR therapies aimed at a variety of phobias and PTSD (e.g., http://www.virtuallybetter.com/).[1] However, a promising technology remains unexplored: computational models of cognition and emotion. Cognitive models (also termed cognitive- or agent-architectures) aim to emulate cognitive processing such as attention, perception, learning, problem-solving, planning and decision-making, and are used by cognitive scientists to advance understanding of the mechanisms and structures mediating cognition.[2] These models are also used in applied settings to improve training and human-system design.[3] Recently, architectures have been developed that explicitly represent emotions: both emotion appraisal processes, and effects of emotions on cognition.[4-9]

While a number of researchers are advocating the use of avatars in VR therapy environments,[10] and promising research efforts exist,[11] little work has been done in coupling synthetic avatars with cognitive-affective architectures. Thus, the potential of cognitive architectures, and associated computational modeling research methods, have not been explored in psychotherapy research and practice. The primary purpose of this paper is to introduce computational cognitive-affective architectures to the cybertherapy community, and describe examples of possible applications in psychotherapy research and practice. These include the enhancement of synthetic avatars in VR treatment and assessment environments (e.g., distinct avatars could be defined to support dynamic, adaptive interaction during social phobia treatment, each with different behavioral characteristics to practice particular situations), and the development of computational models aimed at

advancing our understanding of the mechanisms that contribute to the development of emotional disorders (e.g., inappropriate coping strategies), and those involved in treatment (e.g., cognitive restructuring). The paper is organized as follows. First, I describe a cognitive-affective architecture capable of modeling the dynamic generation of emotions (affect appraisal), and some effects of emotions on cognition (section 2). I then discuss how this architecture could enhance psychotherapy practice (section 3.1) and how it could be used to advance research in the area of affective disorders, by enabling the modeling of the mechanisms of the cognitive-affective interactions mediating both the development and treatment of a range of affective disorders section 3.2).

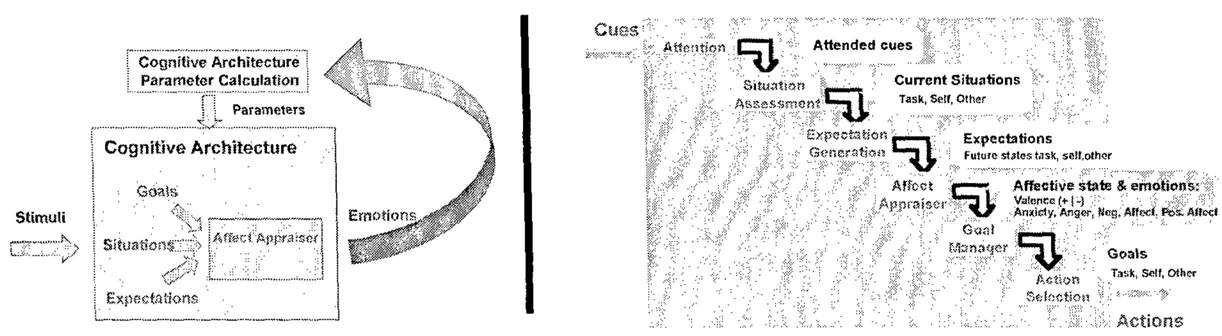
MAMID COGNITIVE-AFFECTIVE ARCHITECTURE

The MAMID cognitive-affective architecture is an integrated symbolic architecture, aimed at emulating aspects of human information processing, with particular focus on the role of emotion in decision-making (see figure 1A). To this end, MAMID models the *cognitive appraisal* process to dynamically generate emotions in response to incoming stimuli, and then models the subsequent *effects of these emotions on distinct stages of decision-making.* Below we describe the MAMID architecture, the generic methodology for modeling effects of emotions (and other individual differences, including personality traits), and a preliminary evaluation.

MAMID ARCHITECTURE

MAMID implements a sequential see-think-do processing sequence (figure 1B), consisting of the following modules: *sensory pre-processing*, translating incoming data into task-relevant cues; *attention*, filtering incoming cues and selecting a subset for processing; *situation assessment*, integrating individual cues into an overall situation assessment; *expectation generation*, projecting current situation onto possible future states; *affect appraiser,* deriving the affective state (both valence and four of the basic emotions) from a variety of external and internal elicitors, both static and dynamic; *goal selection*, selecting critical goals for achievement; and *action selection,* selecting the best actions for goal achievement. These *modules* translate the incoming stimuli (cues) onto the visible behavior (actions), via a series of intermediate internal representational structures (situations, expectations, and goals), collectively termed *mental constructs.*

This "translation" is enabled by long-term memories (LTM) associated with each module, represented in terms of belief nets or rules. Belief nets resemble causal graphs and are well-suited for representing causal relationships among propositions, and at manipulating uncertainty. Rules represent 'IF-THEN' relationships, and are well-suited for representing simple inferences. (Figure 4 shows examples of rules.) *Mental constructs* are characterized in terms of a number of attributes (e.g., familiarity, novelty,



A B

Figure 1. (A) Modeling Affect Appraisal and Emotion Effects within a Cognitive Architecture; (B) MAMID Cognitive Architecture: Modules & Mental Constructs

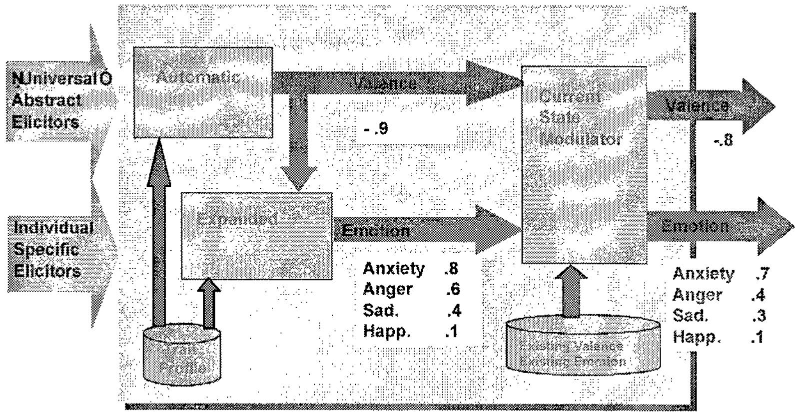


Figure 2. Affect Appraisal Model

salience, threat level, valence, etc.), which collectively determine their processing; that is, the likelihood of a cue will be attended, situation derived, goal or action selected, etc.

The Affect Appraisal module plays a central role in MAMID (see figure 2). It incorporates elements of several recent appraisal theories: *multiple*-levels[4,12,13] and *multiple stages.*[14] The *multi-level structure* generates both a *low-resolution assessment* of the current set of stimuli, in terms of a valence, and a *higher-resolution categorical assessment,* in terms of four of the basic emotions: anxiety/fear, anger, sadness, happiness. Its *multi-stage structure* uses both *universal elicitors* (e.g., novelty, threat level, pleasantness, unexpectedness), to generate the valence using an *automatic appraisal* (roughly corresponding to the largely 'hardwired', 'primitive' appraisal components), and more *cognitively-complex and idiosyncratic elicitors* (e.g., individual history, expectation- and goal-congruence), to generate a categorical assessment using an *expanded appraisal.*

The resulting affective states then influence processing in several ways: (1) they are used directly in the rules selecting the agent's goals and actions; (2) they influence the speed and capacity of the architecture modules; (3) they influence mental construct ranking, thus determining whether a specific cue or situation is processed, or specific goal selected. The last two effects have been a particular focus of this effort, and aim to emulate some of the empirically-identified mechanisms of emotion effects within the perceptual and cognitive apparatus, as outlined above.

GENERIC STATE AND TRAIT MODELING METHODOLOGY

MAMID uses a previously described methodology for modeling state and trait effects within a cognitive architecture,[5,15] which consists of mapping particular state / trait profiles (e.g., high trait and state anxious individual) onto specific architecture parameter values (figure 3). These parameters then control processing within individual architecture modules. Functions implementing these mappings were constructed on the basis of the available empirical data. For example, reduced attentional and working memory (WM) capacity, associated with anxiety and fear, are modeled by dynamically reducing the attentional and WM capacity of the architecture modules, which then reduces the number of constructs processed (fewer stimuli attended, situations derived, expectations generated, etc.). Attentional threat bias is modeled by higher ranking of threatening cues, thus increasing their likelihood of being attended, and by higher ranking of threatening situations and expectations, thus increasing the chances of a threatening situation / expectation being derived. Trait-linked structural differences in LTM are supported by allowing the flexible selection of alternative LTM clusters, reflecting distinct personality traits (e.g., selection of clusters with greater proportion of threat- and self-related schemas to represent individuals with high trait-anxiety (high neuroticism). Traits also influence the dynamic characteristics

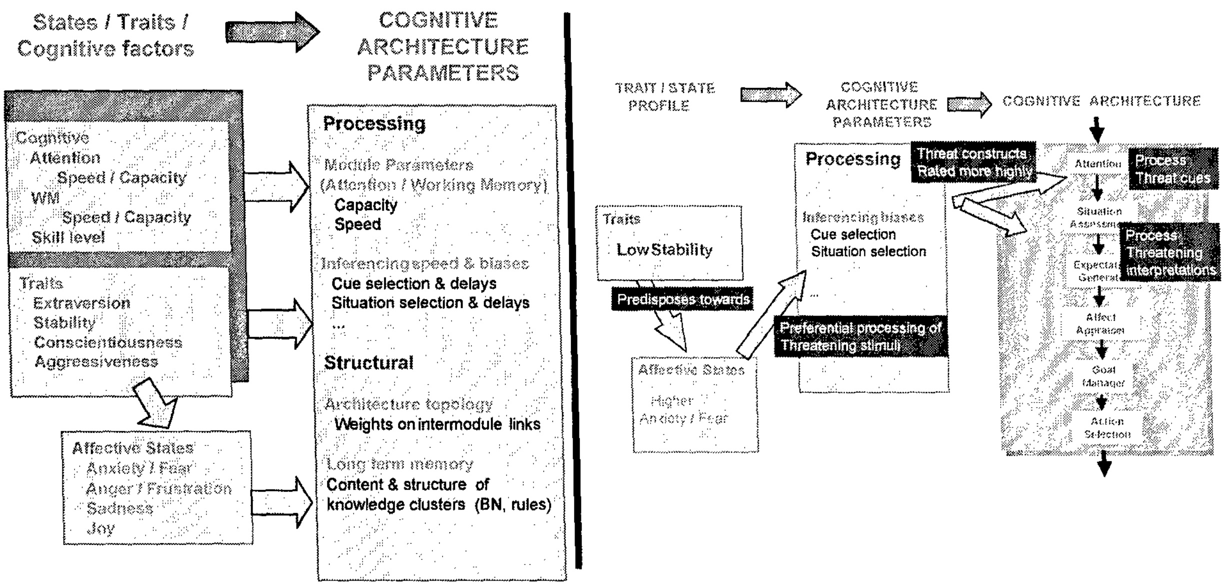


Figure 3. (A) Parametric State / Trait Modeling Methodology; (B) Modeling Threat-Bias Effects Associated with Trait and State Anxiety

of the emotional responses (ramp up, decay, and maximum intensities).

There are several advantages of this methodology for state-trait effect modeling: *(1)* it facilitates rapid modeling of a broad range of distinct individual profiles; (2) the rich architecture parameterization allows the definition of additional high-level individual characteristics (e.g., obsessive-compulsive); (3) it provides a means of integrating the possibly conflicting effects of multiple, interacting traits and states, much as these influences interact in humans.

RESULTS

Feasibility of the model was demonstrated in the context of a simulated peacekeeping scenario, where separate instances of the architecture controlled the behavior of 'stereotypical' unit leaders ('anxious', 'aggressive', 'normal'). The same set of external stimuli triggered distinct emotions and emotional response patterns in the different stereotypes (e.g., higher anxiety levels in the 'high anxious' stereotype), and their effects on decision-making then caused differences in observable behaviors (e.g., slower movement and more communication behaviors in the anxious stereotype). The MAMID architecture is domain-independent, to facilitate transitions to other domains, including psychotherapy.

APPLICATIONS OF COGNITIVE-AFFECTIVE ARCHITECTURES IN PSYCHOTHERAPY

Below we describe how the MAMID cognitive-affective architecture could be used to enhance the effectiveness of therapeutic VR environments, as well as how it could advance our understanding of the etiology and treatment of a range of affective disorders, by supporting adaptive, dynamic interaction between patients and synthetic avatars.

Applications in Clinical Practice

MAMID's ability to represent a variety of distinct stereotypes (in terms of distinct state-trait profiles), and to control the behavior of synthetic avatars in virtual environments, enables it to generate a broad range of avatar stereotypes, characterized by distinct behavioral repertoires (e.g., 'aggressive audience member', 'angry friend', 'anxious spouse'). The ability to dynamically generate individual idiosyncratic behavior characteristic of these stereotypes then enhances the avatar believability, and effectiveness within therapeutic VR environments.

For example, to treat social phobia, or fear of public speaking, a virtual environment would be

“Supportive” Audience Member Avatar	Rule Respond to Speaker IF (Situation = Speaker talking) THEN (Action = Facial expression: smile) (Action = Head movement: nod) (Action = Utterance: “That’s right”)
Aggressive Audience Member Avatar	Rule Respond to Speaker IF (Situation = Speaker talking) THEN (Action = Facial expression: frown) (Action = Head movement: shake) (Action = Utterance: “I don’t think so”)

Figure 4. Examples of MAMID Rules Controlling Action Selection in Two Distinct Stereotypes, Controlling Avatars in a “Fear of Public Speaking” Application

populated by synthetic avatars displaying particular characteristics that trigger undesirable symptoms (e.g., aggressive individuals would be defined for patients exhibiting fear of public speaking symptoms when confronted with critical or aggressive remarks). The avatars would then generate aggressive or critical behaviors (e.g., frown while producing utterances critical of the speaker-patient). Figure 4 shows examples of two rules that would define distinct behavior sequences for distinct audience member avatars. The ‘optimal’ behaviors triggering the undesirable symptoms would be identified empirically, so that the avatar behavior could be customized to produce the desired level of anxiety in the patient. Once identified, the patient would be exposed to these behaviors to implement the desired therapeutic protocol (e.g., exposure therapy, systematic desensitization). The patient would be able to interact with the avatars (e.g., defend himself against a verbal attack, take time to implement a coping strategy), and the avatar's ability to dynamically respond to these interactions (e.g., back off vs. persist) would then provide a degree of realism and customization that are not currently possible in VR treatment environments. The use of such avatars, embedded within simulated situations, would also enhance assessment.

ADVANCING PSYCHOTHERAPY RESEARCH THROUGH COGNITIVE-AFFECTIVE MODELING

By enabling the construction of computational causal models of cognitive-affective interactions, the MAMID architecture also provides a tool for modeling the etiology and treatment of a variety of disorders, as well as the systematic development of targeted assessment and treatment protocols. In this case MAMID would be used to model specific cognitive-affective processes characteristic of a particular disorder. For example, the positive feedback cycle among symptoms and behaviors characterizing generalized anxiety disorders and phobias could be modeled by representing the increasing predominance of anxiety-related schemas in the patient's long-term memory, increased sensitivity to anxiety-producing stimuli, and generalization across previously neutral stimuli, as the disorder becomes established, all contributing to increasingly avoidant behaviors and withdrawal, characteristic of generalized anxiety. Results of therapeutic interventions could then be modeled by ‘exposing’ the MAMID architecture patient model to repeated simulated inputs, representing particular therapeutic interventions (e.g., cognitive restructuring, systematic desensitization), as well as changing social and environmental contexts. This would then result in the gradual emergence of more adaptive memory schemas and interpretations (in the case of cognitive restructuring aimed at teaching specific anxiety-coping strategies), and diminished sensitivity and reactiveness to previously anxiety-producing stimuli (in the case of systematic desensitization and exposure protocols). Improved understanding of these processes would provide opportunities for more finely-tuned assessment and treatment protocols. Computa-

tional models support the development of more refined theories and the generation of specific experimental hypotheses aimed at validating a particular theoretical model.

SUMMARY AND CONCLUSIONS

While much progress has been made in virtual reality treatment environments, the use of cognitive models to control synthetic avatar behavior has not been explored. In this paper I suggest that the incorporation of such models would greatly enhance the effectiveness of these environments, by enhancing the believability and effectiveness of synthetic avatars, and by supporting the development of customized treatment and assessment protocols.

I described a cognitive-affective computational architecture (MAMID), capable of controlling the behavior of such adaptive avatars. MAMID models affect appraisal processes and the effects of several emotions on distinct aspects of decision-making, thereby enabling the definition of a variety of 'stereotypes', capable of exhibiting distinct patterns of behavior within the VR environments. I provided examples of how the MAMID architecture could be used to enhance believability of synthetic avatars, and thereby enable the construction of customized VR treatment and assessment environments. I also discussed how a computational model of cognitive-affective interactions, and their role in perception and decision-making (including situation assessment, expectation generation and goal management), could be used to advance our understanding of the role of these mechanisms in the etiology, maintenance and treatment of a variety of affective disorders. To this end, I described an example of how MAMID could be used to model a patient suffering from a particular set of symptoms, and how specific interventions could be simulated and represented within the MAMID model.

The development of cognitive architecture in general, and cognitive-affective architectures in particular, is an active research area. Much progress has been made in modeling specific cognitive processing (e.g., acquisition of particular arithmetic skill, perception). While currently there is no validated architecture of cognition, the existing architectures are capable of producing a range of 'stereotypical' behaviors, which would resemble real humans and enhance VR treatment protocols requiring social interaction. The computational modeling methods are also well suited for advancing research in clinical psychology, by allowing the development of models of particular disorders, and exploring the different effects of alternative treatment protocols.

Research programs combining empirical studies with computational modeling are becoming more common in cognitive science. I believe that the modeling methods have matured to the point where similar applications in psychotherapy research can be of great benefit.

REFERENCES

1. Zimand, E., Anderson, P., Gershon, G., Graap, K., Hodges, L. & Rothbaum, B. (2003). Virtual Reality Therapy: Innovative Treatment for Anxiety Disorders. *Primary Psychiatry*, 9 (7), 51-54.
2. Anderson, J. (1990). *The adaptive character of thought.* Hillsdale, NJ: LEA. http://act.psy.cmu.edu.
3. Pew, R.W. and Mavor, A.S. (1998). *Representing Human Behavior in Military Simulations.* Washington, DC. National Academy Press.
4. Sloman, A. (2003). How many separately evolved emotional beasties live within us? In Emotions in Humans and Artifacts, R.Trappl, P. Petta, & S. Payr (Eds.). Cambridge, MA: MIT
5. Hudlicka, E. (2002). This time with feeling: Integrated Model of Trait and State Effects on Cognition and Behavior. *Applied Artificial Intelligence*, 16:1-31.
6. Hudlicka, E. (2003). Modeling Effects of Behavior Moderators on Performance: Evaluation of the MAMID Methodology and Architecture, In *Proceedings of BRIMS-12*, Phoenix, AZ, May.
7. Hudlicka, E. (2004). Two Sides of Appraisal: Implementing Appraisal and Its Consequences within a Cognitive Architecture. In *Proceedings of the AAAI Spring Symposium 2004, Architectures for Modeling Emotion*, TR SS-04-02. Menlo Park, CA: AAAI Press.
8. Gratch, J. and Marsella, S. (2004). A Domain-independent Framework for Modeling Emotion. *Journal of Cognitive Systems Research, 5,* 269-306.

9. Hudlicka, E. and Canamero, L. (2004) (eds.) *Architectures for Modeling Emotion*, TR SS-04-02. Menlo Park, CA: AAAI Press.
10. Gaggioli, A., Mantovani, F., Castelnuovo, G., Wiederhold, B., and Riva, G. (2003). Avatars in Clinical Psychology: A Framework for the Clinical Use of Virtual Humans. *CyberPsychology & Behavior*, 6(2).
11. Pertaub, D.P., Slater, M. & Barker, C. (2002). An experiment on public speaking anxiety in response to three different types of virtual audience. *Presence-Teleoperators and Virtual Environments* 11, 68-78.
12. Leventhal, H. and Scherer, K.R. (1987). The relationship of emotion to cognition. *Cognition and Emotion*, 1, 3-28.
13. Smith, C.A. and Kirby, L.D. (2001). Toward Delivering on the Promise of Appraisal Theory. In *Appraisal Processes in Emotion.* K.R. Scherer, A.Schorr, T. Johnstone (Eds.). NY: Oxford.
14. Scherer, K.R. (2001). Appraisal Considered as a Process of Multilevel Sequential Checking. In Appraisal Processes in Emotion. In *Appraisal Processes in Emotion.* K.R. Scherer, A.Schorr, T. Johnstone (Eds.). NY: Oxford.
15. Hudlicka, E. (1998). *Modeling Emotion in Symbolic Cognitive Architectures*. AAAI Fall Symposium Series, TR FS-98-03. Menlo Park, CA: AAAI Press.

Contact

Eva Hudlicka, Ph.D.
Psychometrix Associates, Inc.
Blacksburg, VA, USA
Tel: (01) 540 552 4803
Email: evahud@earthlink.net

Immune Attack: Building Biologically Based Immune System Simulations for Education and Training

K. Howell, B.A., MBA

Federation of American Scientists, Washington, DC

Abstract: *A growing literature suggests that simulation, visualization and gaming can play an important role in deepening understanding of difficult concepts in mathematics, engineering, and science. Learning sciences research suggests that learning by doing with understanding produces better transfer than mere doing alone.[1,2] Challenge-based simulations can provide students opportunities to receive feedback and revise their thinking, a critical part of the learning process.[3,4] Immune Attack is a simulation game to teach biological concepts related to immunology and wound infection, allowing the student to explore the internal compartments and cells of the human body and visualize immunological processes. Simulations of biological functions at a variety of levels, from subcellular to organ systems, that are easily navigable by instructors and students with a range of backgrounds will provide a rich exploratory environment for learning immunology.*

BACKGROUND

Immune Attack is a simulation game to teach biological concepts related to immunology and wound infection, allowing the student to explore the internal compartments and cells of the human body and visualize immunological processes, including pathology. The game combines three-dimensional visualizations of biological structure and function with advanced educational technologies to provide an introduction to basic concepts in immunology for high school students. *Immune Attack* is intended to be as fun and compelling as the computer games currently played by many adolescents and young adults. Students are motivated with a series of progressively more difficult challenges in a gaming environment in which success depends on increasingly sophisticated grasp of concepts in immunology. The learning experiences are individualized by use of context-sensitive help and dialogues and continuous assessment techniques to determine when the learner is ready to move to a new level. The project is funded by a National Science Foundation Information Technology Research grant.

The goal of this research is to test the hypothesis that visualization of, and immersion in realistic depictions of human biology will be highly engaging to high school students and hold their interest long enough for learning to occur. Advances in cognitive science point to new strategies for increasing the productivity and depth of learning if the learner is continuously given challenges whose solution depends on mastering the material.[2] The game-based simulations that are integral to the gameplay will let learners apply their knowledge immediately in an attempt to defeat a variety of diseases, from simple infections to more challenging infections. The student's success in designing an immune strategy capable of overcoming an array of infectious agents will provide a much richer measure of understanding than standardized tests. Learning is further enhanced if the students are so motivated to meet the challenges that they are eager to ask questions that can help them – and if they are able to get timely, accurate answers tailored to the student and the context of the question.[5]

METHOD/TOOLS

The biological models for the game were developed working closely with prominent immunology researchers and educators. Experienced video game developers are developing the game and assisting in integrating the learning tools. The learning objectives and instructional strategies are being developed in consultation with biology teachers, at both the high school

LEARNING OBJECTIVES	GAME DESIGN/PLAY
General	
The student will comprehend the basic strategies of major pathogens	Simple rules govern the stylized but accurate behaviors of a variety of bacteria, viruses, and toxins.
The student will be able to identify and understand role of key components of the immune system including innate responses, inflammatory responses, and secondary response systems	The player must master the rules that govern the behavior of macrophages, neutrophils, mast cells, NK cells, T and B cells and will be able to guide these cells by following key signals, such as proteins.
The student will have knowledge of how the immune systems and its component results clinical symptoms	Pop up tutorials, a health status bar, and visualizations of the patient provide clinical information to alert the player as to the patient's physiologic condition and introduce medical terminology.
The student will be knowledge about defects in the immune system	Allergies, autoimmune disease, AIDS are included to show the how the disease progression changes in individuals with compromised immune systems.

Table 1. Example Learning Objectives

and college freshmen levels, and with learning research scientists.

Development of valid educational content coupled with simulations of biological components and their processes and interactions is a key component of the project. We have worked closely with leading immunologists and the teachers participating in the evaluation of the game to develop an instructional plan for the game based on introductory curricula, including immunology content, determination of educational objectives, strategy for integration of learning tools into the game, and evaluation of the game. Particular emphasis was placed on determination of appropriate levels of content for the target audience. A sample of the learning objectives is shown in Table 1.

A major challenge of the project was to define the learning content so that it would be easily accessible and understandable both by the biologists who need to ensure that it is correct and the software engineers who will need to instantiate it in code. One of the great challenges in developing reusable software objects is that they are often so difficult to understand that it is easier to build from scratch rather than risk misinterpreting often sparse instructions about how to use legacy objects. We have developed formalisms that minimize the difference between the question "how does this object operate?" and the question "how does the biological system work?" While the details of the implementation may be captured in complex equations, the vocabulary, rules represented, and terms used to describe inputs and outputs are all easily understandable in biological terms.

Our formalism is based on the Universal Modeling Language (UML).[6] UML tools were used to build a formal map of knowledge about the immune system that includes named variables and formal relationships (that should be covered by the ontology), information about rules and equations describing behavior, clear English descriptions of what is being represented available through some kind of introspection, the referenced source of the information encapsulated, and mechanisms for maintaining version control. The structures extend the structures of the ontology to ensure consistent inheritance of both fields and functions. For example, a component representing the essential elements of a cell can be extended to represent a generic leukocyte that can in turn be extended to represent a generic lymphocyte and then a specific B cell. Such structures provide a seamless connection between ontologies and the framework of software objects. It provides a way to ensure that functionality and updated data at the root of an object tree are accurately propagated.

The central challenge of the game is to teach rules to a set of players that represent all the

important elements of the immune system (e.g., macrophages, neutrophils, dendritic cells, T, B, and NK, etc.) These rules will operate the software objects representing the cell types. As rules are turned on, more complex phenomena will be exposed. A key part of the educational game is understanding the way the characters (cell types) pass messages to each other interact.

The levels of the game involve an ability to address different attack strategies. The gameplay starts with a simple infection that can be mastered with the innate immune system. Progressively more sophisticated viruses and bacteria require mastery of more sophisticated strategies and understanding how to use an increasing number of immune cells. See Table 2 for a sample of the levels. The core challenge and excitement of the game will is being presented with a novel class of infection or a known infection agent at a new site. Each will simulate the progression of an actual disease – which can be as simple as a simple skin infection or as complex as AIDS or TB. At an early stage, for example, a player may be confronted by a simple skin infection that can be addressed by using macrophages and the innate immune response. The key issue is telling friend from foe. As a player becomes increasingly comfortable with play at this level, a new pathogen is introduced that multiplies so fast that the macrophages are overwhelmed. A new strategy must be developed to send signals recruiting help – say from neutrophils. This means understanding the signaling and the combined behaviors of the senders and receivers of the signal. As the player becomes comfortable managing an array of diseases at this level, she is confronted with infectious agents that operate from within friendly cells such as viral attacks. This requires determining a strategy for detecting the invasion and recruiting specialized help from specialized T cells. The player must find ways to send messengers (e.g., dendritic cells) to lymph nodes that may be distant from the infection. Simulations capable of supporting this kind of game play must be able to operate at many different levels and at many scales.

At each level the student can elect to get a briefing on the material or elect to discover the material by experimentation. Help is available at all times through the game's artificial intelligence and from teachers and peers.

EVALUATION

The game will be used to supplement immunology taught as a part of biology courses given to high school students and will be evaluated in high school biology classes. The project will be evaluated based on the degree to which it successfully addresses the research challenges identified above. These challenges center on three main questions:

Game Play Levels (partial list)	
LEVEL 1:	**Innate Immunity-1**
The student will be able to analyze the concept of how immune cells recognize 'self' peptides versus 'non-self' peptides	The challenge is to train macrophages by selecting receptors that identify pathogens and then choose functions that help to destroy the pathogens
LEVEL 2:	**Innate Immunity-2**
The student will understand how cytokines and other proteins that can recruit neutrophils to the infection site	The challenge is to train macrophages to release the appropriate signaling proteins and train neutrophils in the blood stream to recognize the signal and behave appropriately
LEVEL 3:	**Adaptive-1**
The student will understand how dendritic cells become active and carry signals to recruit T8 cells in lymph nodes	To succeed, the player must train a dendritic cell and guide interaction with T to generate clonal expansion by locating, then matching the receptor to the ligand
LEVEL 4:	**Additional levels of sophistication**

Table 2. Game Play Levels

- Has the project developed biologically correct, visually compelling simulations of the immune system that can be easily navigated by people without specialized technical proficiency?
- Do the simulations effectively incorporate state-of-the-art open architectures and interoperability frameworks that will both facilitate revisions and augmentations for a variety of purposes and encourage use of simulation components in the work of others?
- Can the simulations be used in conjunction with existing instructional tools to develop a prototype instructional system that incorporates a variety of assessment, feedback, and augmentation tools?

For the first two research challenges, assessments will be conducted through workshops that are planned annually for each year of the project. A panel of experts will be convened as part of the workshops to assess the biological accuracy of the simulations at various stages of design and development and the interoperability frameworks. The panel will consist of biologists, immunologists, computational biologists, and medical professionals. The evaluation plan for the instructional game will be developed with advice by the Education Advisory Panel. The evaluation will focus on four key questions:

1. Does use of the instructional game improve the performance of students on tests now given by instructors in applicable courses?
2. Does the system improve understanding in areas of immunology that are particularly difficult to master?
3. Does the system increase student interest in science and their interest in a career in science?
4. Does the effect of 1-3 depend significantly on sex, ethnicity, or other characteristics of the learners?

NOVELTY/DISCUSSION

Computer games hold special interest to a generation who has grown up with them, and as such, they show promise as educational tools. Whether this is due to the inherent challenge built into game play, the richness of graphics presented to the user, the opportunity to interact with other users (in web-based games), the story or context in which the game is couched, or some other feature is an important part of this research project. Exploiting the inherent motivational aspects of games and simulations for education and training must be based on a sound understanding of which features of these systems are important for learning and why.

The instructional game will be used to supplement immunology taught as a part of introductory biology courses given to high school students. The research will provide the basis for building engaging simulations that teachers can use to convey subtle concepts in the immune system and infection control. It should improve biology education by presenting educational materials in a way that is engaging and useful to people with a variety of interests and backgrounds. A student motivated to learn the complexities of the immune system can also have the basis for understanding a wide range of biological concepts. The interest generated by the game could encourage students from many different backgrounds to enter a scientific or medical profession. While the initial target audience will be senior high school and first-year college students, we expect that the system will facilitate learning for a broad class of learners, including the many professionals that need to master elementary concepts in infection and infection control – such as people who now must be trained to deal with potential biological attacks. The research will result in tools that can assist people to improve their own health care by presenting difficult concepts in ways that a typical patient can understand. It is also likely to help research specialists get a clear, visual understanding of the way their research specialties fit into the extravagantly complex network of operations that combine to make the immune system.

REFERENCES

1. Barron, B.J., D.L. Schwartz, N.J.; Vye, A. Moore, A. Petrosino, I. Zech, J.D. Bransford, and the Cognitive and Technology Group at Vanderbilt. Doing with Understanding: Lessons from research on problem and project-based learning. Journal of Learning Sciences 7 (3 and 4): 271-312.

2. John D. Bransford, Sean Brophy, and Susan Williams. "When computer technologies meet the

learning sciences: Issues and opportunities" in Journal of Applied Developmental Psychology, 21 (1) pp. 59-84.

3. Black, P., and William D. 1998. Assessment and classroom learning. In Assessment and Education. Special issue of Assessment in Education: Principles, policy and practice 5 (1):7-75. Carfax Pub. Co.

4. Vye, N.J. , D.L. Schwartz, J.D. Bransford, B.J. Barron, L. Zech, and Cognition Technology Group at Vanderbilt, 1998. SMART environments that support monitoring, reflection, and revision. In Metacognition in Educational Theory and Practice, D. Hacker, J. Dunlosku, and A. Graesser, eds. Mahwah, NJ: Erbaum.

5. Graesser, A. C., VanLehn, K., Rose, C., Jordan, P., & Harter, D. (2001). Intelligent tutoring systems with conversational dialogue. *AI Magazine*, 22, 39-51.

6. Booch, G., Rumbaugh, J., & Jacobson, I. (1999). The unified modeling language user guide. Reading, MA: Addison-Wesley.

Contact

H. Kay Howell, B.A., MBA
Federation of American Scientists
1717 K. St., NW
Suite 209
Washington, DC 20036
Ph: 202.454.4685 Fax: 202.6751010
khowell@fas.org

General Training of Spatial Abilities by Geometry Education in Augmented Reality

H. Kaufmann[1], K. Steinbügl[1], A. Dünser[2], J. Glück[2]

[1] Institute of Software Technology and Interactive Systems, Vienna University of Technology
[2] Institute of Psychology, University of Vienna

Abstract: *Geometry education has proven as one powerful means of improving spatial abilities, an important component of human intelligence. In the first part of this paper we summarize our development of a system that uses collaborative augmented reality as a medium for teaching, and uses 3D dynamic geometry to facilitate mathematics and geometry education. Our immersive collaborative educational application, specifically developed for geometry education, serves as the basis of a comprehensive evaluation study regarding its efficacy in training spatial abilities. The main contribution is the description of evaluation design including the test instruments, learning tasks and practical experiences with using our system for actual training of high school students. Results of a pre-study with spatial ability tests in high schools are presented. They point to interesting gender-specific differences of strategies when solving spatial ability tests, which have not been reported in literature before.*

INTRODUCTION

Spatial abilities present an important component of human intelligence. Many studies have shown that spatial abilities can be improved by well-designed trainings.[32] Geometry education has proven as one powerful means of improving these skills;[10] recently, a number of training studies have shown the usefulness of virtual reality (VR) in training spatial ability.[9,29] However, little to no work has been done towards systematic development of VR applications for practical education purposes in this field.

- No VR/AR application for actual use in high school or higher education has ever been developed with the main purpose of improving spatial skills.
- Hardly any evaluations can be found in literature which give hints to the actual learning transfer from a VR/AR learning environment to the real world.

The authors initiated a national research project which addresses these two key issues by developing a prototype AR system for geometry education. As a pilot study for this proposal, a three dimensional geometric construction tool called Construct3D[16-18] has been developed that serves as a platform for our work. A comprehensive evaluation study will be conducted in order to study the general and differential effects of the training on several components of spatial ability.

In this paper, we briefly describe our experiences in developing and using Construct3D in high school geometry education. To provide a natural face-to-face setting for teachers and students, this system uses an immersive setup, more specifically a collaborative augmented reality (AR) setup, based on see-through head-mounted displays (HMD). The main advantage of using AR is that students actually see three dimensional objects which they until now had to calculate and construct with traditional - mostly pen and paper - methods (Figure 1). The face-to-face setting allows for traditional pedagogic communication.

It is important to note that while *geometry education* software shares many aspects with conventional computer aided *design* software at a first glance, its aims and goals are fundamentally different. Geometry education software is not intended for generating polished results, but puts an emphasis on the construction process itself. While relatively simple geometric primitives and operations will suffice for the intended

Figure 1. Students are working in 3D space with Construct3D.

audience of age 10 to 20 (especially 10 to 14), the user interface must be both intuitive and instructive in terms of the provided visualizations and tools. Commercial CAD software offers an overwhelming variety of complex features and often has a steep learning curve. In contrast, geometry educators are interested in simple construction tools that expose the underlying spatial process in a comprehensive way. The interface might be restricted to their students needs. In accordance to that our aim with Construct3D was not to create a professional 3D modeling package but a simple and intuitive 3D construction (not animation) tool in an immersive environment for educational purposes.
The main part of our work concentrates on our evaluation study - the test instruments, participants and the study design. We intend to address the following research questions in our evaluation study:

1. Effect of the training on performance in tasks central to the training;
2. Transfer of the training effect to more distant spatial tasks;
3. Effect of the training on strategy use in central and distant spatial tasks;
4. Aptitude-treatment interactions: Dependence of individual training effects on pretest spatial ability, verbal ability, and reasoning ability;
5. Gender differences in training effects.

RELATED WORK

For the development of any educational VR/AR application, technological, domain specific, pedagogical and psychological aspects are of importance. Accordingly, literature from different and diverse research areas relates to our work: VR/AR collaborative distributed systems, desktop 3D modeling, immersive modeling, educational 2D/3D applications, dynamic 2D geometry, parametric CAD, pedagogic theories such as constructivism or activity theory and psychological literature from the field of spatial ability research. We will briefly mention work related to training and psychological aspects of this paper. For a comprehensive overview of related work we refer to.[16]

Educational VR Applications

Since the early 1990th researchers have been working on virtual reality applications for purely educational use.[1,5,22] In the area of mathematics education the most recent and most advanced project is CyberMath.[34] CyberMath is an avatar-based shared virtual environment aimed at improving mathematics education. It is suitable for exploring and teaching mathematics in situations where both the teacher and the students are co-present and physically separated. A very good summary of educational and training applications is given by Mantovani.[25]

Training Spatial Abilities in VR

Training of spatial abilities in VR is of strong interest in application areas such as surgery,[35] navigation and way finding,[8] for rehabilitation of patients with psychiatric illnesses such as traumatic stress disorder, schizophrenia, and Alzheimer's disease[28,29] or for pre-flight space training.

A recent article by Durlach et al.[9] gives a very good overview of work that has already been done in the area of enhancing spatial skills within virtual environments but mainly identifies the indispensable need for comprehensive future research in this area.

Spatial Cognition

Psychological literature on spatial cognition ranges from studies on the way people process simple spatial objects to studies about how people orient themselves in real environments. In the following, we give a brief introduction into spatial cognition with references to related work. Several authors[6,13,23,33] suggested how spatial ability can be structured into sub domains. Most of the proposed structures focus on relationships and similarities among spatial tests and were developed through analysis of test intercorrelations. The results of structural analyses of spatial ability are highly convergent. In addition to some simple, basic performance aspects, at least two factors are consistently reported: "Spatial Relations" (as labeled by Lohman[23]), that is, speeded mental rotation, and "Visualization", which includes all complex, multi-step spatial tasks. Tasks involving three-dimensional mental rotation are somewhat intermediate and have been grouped into each of these two factors. Tasks requiring participants to imagine different perspectives either form a third factor or are grouped into Spatial Relations.

A different approach to thinking about spatial cognition is by analyzing the processes people actually use to solve spatial tasks. Basically, all spatial tasks can be solved in different ways, and the more complex a task is, the more different strategies can be used to solve it (overview in[24]). People differ in the strategies they use, and people shift their strategies within a task if necessary. A basic distinction is between holistic and analytic strategies.[11] Holistic strategies involve representing and manipulating spatial information "in a spatial way", that is, mentally using information about spatial relations between elements in the mental representation. A person using holistic strategies imagines, for example, how a stimulus figure is rotated, or how a two-dimensional shape can be folded into a three-dimensional object. Analytic strategies reduce spatial information to an essentially non-spatial, serial format. For example, a route can be represented as a list of landmarks, and the spatial relations among the patterns on a cube can be represented as a list of relations among pairs of patterns. Thus, the complexity of spatial information is reduced, and the focus is on parts of the object or the environment rather than on the object as a whole. Compared to holistic strategies, analytic strategies usually take more time, but less mental effort, as the information represented is less complex. Note that analytic and holistic strategies should not be viewed as mutually exclusive categories.

Gender differences in strategy use have frequently been found in studies of environmental orientation and navigation. Men more often acquire map-like knowledge about their environment, use Euclidean information, and are aware of relative directions, whereas women more often rely on landmarks and represent routes as lists of landmarks. These gender differences have been found in self-reported strategy use in new environments[21] and in use of landmarks and Euclidean information in learning routes from maps and giving directions.[4] With respect to spatial tests, gender differences in strategy use have not been studied much, but at least one[11] found that men more often used holistic strategies than women, and women more often used analytic and mixed strategies than men in two different spatial tests.

Figure 2. Two students collaborate in our standard lab setup, wearing an HMD, holding a wireless pen and panel. All devices are optically tracked.

CONSTRUCT3D

Construct3D is based on the Studierstube AR system[30] and uses augmented reality to provide a natural setting for face-to-face collaboration of teachers and students.

Hardware Setup

In our standard Studierstube setup, we have 2 collaborating users wearing HMDs for a shared virtual space, and holding fully tracked interaction props in their hands. One dedicated host with 2 graphic ports renders stereoscopic views for both users. We are using this setup for demonstrations and evaluations. Other setups for educational use have been reported in.[16]

Software Design

The current version of Construct3D offers functions for the construction of points, two-dimensional geometric primitives and three-dimensional geometric objects. It provides functionality for planar and spatial geometric operations on these objects, allows measurements, features structuring of elements into layers and offers basic system functions.

Construct3D promotes and supports exploratory behavior through dynamic geometry. A fundamental property of dynamic geometry software is that dynamic behavior of a construction can be explored by interactively moving individual defining elements such as corner points of a rigid body. It can be seen what parts of a construction change and which remain the same. The histories of constructions as well as dependencies between geometric objects are maintained. Experiencing what happens under movement allows better insight into a particular construction and geometry in general.

At its start Construct3D initializes a 3D window which has maximum size to cover the "whole" virtual space. The user interface is initialized, the menu system is mapped to a hand-held tracked panel called the personal interaction panel (PIP). The PIP allows the straightforward integration of conventional 2D interface elements like buttons, sliders, dials etc. as well as novel 3D interaction widgets. Haptic feedback from the physical props guides the user when interacting with the PIP, while the overlaid graphics allows the props to be used as multi-functional tools.

All construction steps are carried out via *direct manipulation* in 3D using a stylus tracked with six degrees of freedom. In order to generate a new point the user clicks with his pen exactly at the location in 3D space where the point should appear. Users can easily switch between point mode (for setting new points) and selection mode (for selecting 3D objects). We omit a detailed description of the user interface in this context.

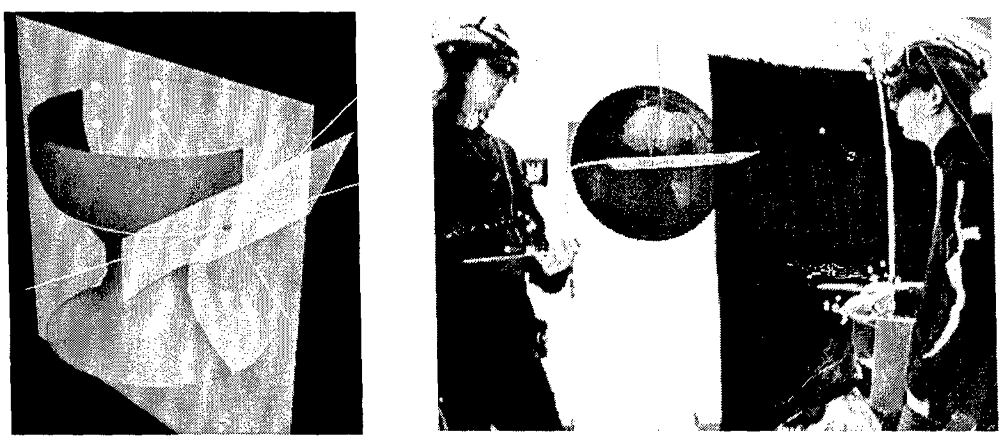


Figure 3. Left: Surface of revolution with the tangential plane in a surface point. Right: Two students are collaborating to solve the problem. Vienna is marked on the globe and a geostationary satellite (in the equatorial plane) is given too.

All operations consistently support dynamic modifications of their input elements and re-evaluate the resulting elements accordingly.

LEARNING TASKS

To illustrate the type of geometric examples and learning tasks that are best suited for teaching geometry with Construct3D we list actual educational tasks and examples that we used in previous evaluations. Students of age 16-18 who have geometry classes in high school worked collaboratively with a teacher and another student on these examples.

Surface of Revolution

Given an axis, students have to construct a surface of revolution by rotating a B-Spline curve (cubic, 5-6 control points) around the axis. The control points can dynamically be modified at any time resulting in a change of the surface of revolution.

In the next step, the tangential plane in an arbitrary point P of the surface must be found. Therefore pupils have to construct a meridian curve through P which they get by intersecting the surface with a plane through the axis. They also have to rotate the point around the axis to get its circle of latitude on the surface of revolution. The two tangents to the circle of latitude and to the meridian curve in P define the tangential plane. Figure 3 (left) shows the result of this construction.

Dynamic modifications of the start elements and all constructed parts allow to study and explore the construction. Students see immediately and learn that the surface normal in any point of the surface intersects the surface's axis, which is an important property of surfaces of revolution.

Adjusting a Satellite Dish

In the second problem a satellite dish, positioned in Vienna, has to be adjusted to point to the TV-SAT2 satellite, which is given. Students have to translate this real life problem into a geometric problem to be able to identify two angles which are needed to adjust the satellite dish. Web links are presented with additional information about geostationary satellites; given images help to understand and translate the problem. The given virtual scene in Construct3D (Figure 3 right) shows a model of earth (with texture) to help pupils find the correct places on earth and to immerse them further into the problem.

Deflection Sheave

A rope is being redirected from one given position to a final given position. Two deflection sheaves, which are drawn as circles redirect the rope. They have to be constructed as well as the piece of connecting rope between them. Only start and end position of the rope are given as well as the mid point of the first deflection sheave. Deflection sheaves can be found at skiing lifts, elevators and in many other machines. Students got an explanatory draft to lead them towards a correct solution.

USABILITY EVALUATIONS

System Evaluation

Based on feedback from many trials with real high school students, we continuously improved Construct3D over a period of 3 years. In early 2004, we conducted a larger study based on interviews and the standardized ISONORM 9241/10 usability questionnaire[26] after systematic exposure of 15 students (9 male, 6 female) to Construct3D. A number of training exercises that fit the students' 11th and 12th grade curricu-

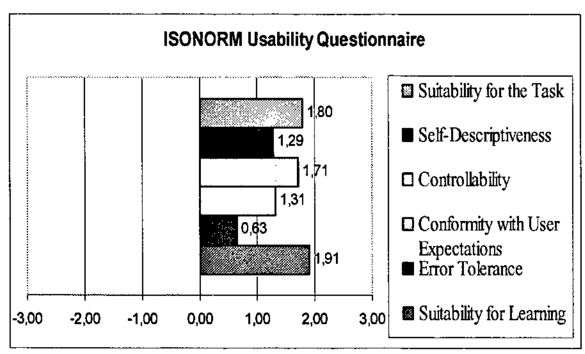


Table 1. summarizes the results of the ISONORM usability questionnaire in the 6 categories "suitability for the task," "self-descriptiveness," "controllability," "conformity with user expectation," "error tolerance," and "suitability for learning".

lum were designed by us and then worked through by students from two high schools with the aid of their teachers. All students attended to geometry classes (descriptive geometry) since the beginning of grade 11. Each of them participated in 5 training sessions lasting 6 hours. Our main objective was to at least informally assess the usability and potential of our system and method for real high school work.

Construct3D Usability Results

At the end of all training sessions students had to answer an ISONORM usability questionnaire. Two questions regarding self-descriptiveness of the application had to be removed since they were related to desktop applications only. Afterwards students answered general questions regarding user acceptance, user behaviour, technical requirements and organisational aspects.

A closer look at the data reveals that the categories "suitability for learning" and "suitability for task" received the highest grading which is very important in this context. In our opinion the highest priorities for an educational application that complies with pedagogic theories such as constructivism are that it (1) is easy to use and requires little time to learn, (2) encourages learners to try new functions and (3) can be used consistently and is designed in a way that things you learned once are memorized well. These are exactly the items that students rated very high. Nearly all students reported that they can imagine using the current version of Construct3D in high school or university education.
The categories "self-descriptiveness" and "conformity with user expectations" got lower grades than the rest. The self-descriptiveness of Construct3D is currently improved by adding better labeling and tool tips to widgets on our panel in order to explain all menu items. We are also restructuring the menu system to give a better overview of the functionality.

Some of the students reported negative side effects after working in the virtual environment. One female student reported headache and eyestrain after 20 minutes of work in the virtual environment but did not stop working and wanted to use Construct3D again (in total she worked for 3 hours with the system). In retrospect we know that our one hour lessons were simply too long for continuous work with an HMD. Since negative side effects are a general problem when working with HMDs and influence the user's subjective experience of a VR/AR environment considerably they are relevant to all VR/AR applications that use HMDs. We identified some possible reasons of cybersickness that may be relevant to our virtual environment such as accommodation problems, low frame rate, lag or bad fitting helmets. In the meantime we already reduced some of these negative side effects (using light weight bicycle helmets and increasing frame rate).

We must stress that we designed Construct3D to be a valuable *addition* to traditional or computer aided geometry education and *not a substitute* of it. A very reasonable time for working and teaching with Construct3D during a class is about 20-30 minutes. According to our observations, this would guarantee that less than 5% of all students feel any negative side effects such as eyestrain or even headache. Of course it would be desirable to find the exact reasons of cybersickness and ways to avoid it – as pointed out by other researchers.[20]

EVALUATION DESIGN ON TRAINING SPATIAL ABILITIES

The presented system serves as a base of further research and allows to do more in depth evaluations of various aspects regarding VR/AR learning that have not been studied before.

Currently we focus on the largest evaluation with Construct3D yet, involving over 250 students. It concentrates on 5 main questions about training and improving spatial abilities as mentioned in the introduction.

Test Groups

We will conduct a pre-/post-test experiment with four different training groups and one untrained control group. At pre-test, all participants will be presented with a battery of spatial tests (including strategy assessments) and tests of verbal and reasoning ability. Then, each participant will be randomly assigned to one of five groups:

a. Untrained control group: Participates in the

pre- and post-test but does not receive any training;

b. Traditional school group: Participates in the pre- and post-test, but is taught geometry in their normal school classes between pre- and post-test with traditional paper & pencil methods;
c. Modern instruction/school group: Participates in the pre- and post-test, but is taught geometry in their normal school classes between pre- and post-test on the computer using CAD software;
d. Individual tutoring group: works with a tutor using standard teaching methods without Construct3D;
e. Construct3D group: works with Construct3D.
f.

The reason we use an individual tutoring group is that this condition is probably "harder to beat" than standard class-wise Descriptive Geometry (DG) instruction. Tutors are likely to use hand drawing and sketching as teaching methods, thus, they will provide a "hands-on" experience that has proven to be particularly effective in other training studies. However, we expect the Construct3D tutorial to lead to broader transfer of training gains than the tutoring. As women more often than men use analytic strategies on spatial tests, the Construct3D training, which focuses on visualization, might have different effects on female than on male participants. It is certainly interesting to see how different types of training affect such differences.

Between pre- and post-tests five training sessions will be conducted. Participants will be students in their 11th and 12th year of schooling, attending secondary schools in Vienna. Austria has several different secondary-education curricula, some of which have a focus on the natural sciences, including Descriptive Geometry (DG). DG classes start in the 11th form.

Instruments

The following instruments will be presented to participants at pre- and post-test. A battery of spatial tests as listed below will be used:

- Mental Rotations Test (MRT[36]), German version by:[27] speeded mental rotation.
- Purdue Spatial Visualization Test: Rotations (PSVT:R[12]): shortform: mental rotation combined with visualization.
- Mental Cutting Test (MCT[7]): shortform: visualization.
- Differential Aptitude Test: Space Relations (DAT:SR[12]): shortform: visualization.
- Spatial Orientation Test (SOT[19]); mental rotation – large scale
- Judgement of Line Orientation Test (JLO[3]); visuospatial perception and processing.

Reasoning and Verbal Ability Tests:

- "Letter Sequence": subtest from the German intelligence test battery "Wilde Intelligenz Test" (WIT) by:[14] shortform
- "Verbal analogies": subtest from the German intelligence test battery "Berliner Intelligenzstruktur Test" (BIS)[15]
- "Vocabulary" ("Wortschatztest" WST):[31] shortform

Strategy Questionnaire: Assessment of different aspects of holistic vs. analytic strategies, the most important ones are "Visualization / Imagination" vs. "Non-visual Reasoning / Thinking" and "Focus on the object as a whole" vs. "Focus on details".

These tests have also been used at two preliminary studies that we did in Austrian high schools. In the first study 42 students (39 males, 3 females; aged 17-19 years, 11th grade) participated, in the second bigger one there were 79 students (44 females, 33 males, 2 unknown; aged 16-19, 11th and 12th grade). Due to time restrictions in schools, we developed two short versions of each test except the MRT which was used in its full length. We split the tests (PSVT:R, MCT, DAT:SR) into halves by simply assigning all odd items to test version A and all even ones to test version B. In order to eliminate obvious inequalities, we thereafter exchanged some items or assigned some items to both test versions. The final test forms consisted of 15 (MCT and PSVT:R) respectively 25 (DAT:SR) items. The time limits set for the tests were calculated based on the regular test versions and the number of problems selected for the short versions and were therefore 12.5 minutes for the PSVT:R, 12 minutes for the MCT and 12.5 minutes for the DAT:SR. Our short test

versions had reliability coefficients (Cronbach's alphas) ranging form 0.66 to 0.90.

PRELIMINARY STUDY

The purpose of the preliminary study was to examine some frequently employed spatial tests that contain different kinds of tasks and are supposed to affect different aspects of spatial ability in regard to performance, strategy use and the relation between these two variables. More precisely, we aimed to find answers to the following questions:

a. How do performances in different spatial ability tests correlate with each other and what is the nature of the relationship to cognitive tests measuring analytical abilities (reasoning and verbal abilities)?
b. Are there *intra*-individual differences in strategy use across tests? Do different spatial tests evoke different strategies?
c. Are there *inter*-individual differences in the use of strategies? Do participants show a tendency to use holistic or analytic strategies irrespective of the nature of the task?
d. How are performance and strategy use associated with each other?

RESULTS

The first study (39 males, 3 females; aged 17-19 years, 11th grade) aimed to examine associations and intra- and inter-individual differences between several spatial ability tests regarding performance and strategy use and to make connections between performance and strategy use. The spatial ability tests used were the MRT, the PSVT:R, the DAT:SR and the MCT together with reasoning (verbal and non-verbal) and verbal ability (vocabulary) tests.

In an explorative pre-study subjects were asked to solve problems of these tests by thinking aloud. The findings of this pre-study suggest that a major part of these problems (especially PSVT:R and DAT:SR problems) can be successfully solved not only in a spatial (holistic) way but also by using analytic non-spatial strategies. The way the MCT was solved indicates that (geometry) knowledge may also be an important factor.

Applying a factor analysis on the test scores 3 factors could be identified: spatial ability (with loadings of the 4 spatial ability tests as well as a lower loading of non-verbal reasoning tests), reasoning ability (with loadings of both reasoning tests), and vocabulary. There were positive significant correlations between the DAT:SR and the PSVT:R on one hand and the non-verbal reasoning test on the other hand. This finding goes together with the one from the pre-study indicating that DAT:SR and PSVT:R scores are not a pure measure of "real" spatial (holistic / visualization) ability but confounded by reasoning abilities.

Analyses of the strategy use questions reveal that, on the one hand, there are differences in strategy use on an inter-individual level: Significant positive correlations over the tests indicate that subjects tend to certain strategies that are rather independent from the kind of spatial task. On the other hand, these personal strategy tendencies are not completely unaffected by the nature of the spatial test: The use of holistic strategies is significantly higher for the MRT as for the other three spatial tests.

When drawing the conjunction between performance and strategy use, we found that there were no correlation between performance and strategy regarding the DAT:SR, the PSVT:R, and the MCT, i.e., subjects using mainly holistic strategies could *not* achieve higher scores than subjects using mainly analytic scores. However, there was a significant correlation between strategy use and performance in the MRT, indicating that "holistic" subjects scored slightly better than "analytic" subjects.

Considering these results, it seems that the MRT stands out from the other three spatial tests we used in this study: It is processed more holistic than the other tests and the use of holistic strategies has more (positive) influence on the performance compared to the DAT:SR, the PSVT:R and the MCT.

Altogether, our findings give some evidence that spatial ability tests – in particular the PSVT:R and the DAT:SR - can be successfully solved not only with "real" spatial (holistic) strategies but also with analytical strategies – at least as long the time limit set is ample enough as these analytical strategies are generally more time-consuming than holistic processing. Results

	Component	
	1	2
PSVT:R score	**,661**	,196
MCT score	**,735**	-,141
MRT score	**,632**	,231
DAT score	**,836**	,083
WIT score	,187	**,888**
JLO score	**,826**	-,056

Table 2. Component matrix for male participants

	Component	
	1	2
PSVT:R score	**,689**	,363
MCT score	**,761**	,269
MRT score	,094	**,890**
DAT score	**,707**	,481
WIT score	**,736**	,392
JLO score	,211	**,682**

Table 3. Component matrix for female participants

from an explorative pre-study also suggest, that knowledge plays an important role in the solving process of the MCT. Though our results are based on a rather small sample it seems to be justifiable to draw the tentative conclusion that the scores of spatial ability tests do not necessarily reflect "real" spatial abilities in the sense of holistic processing and visualization and are also affected by other factors like reasoning abilities and knowledge. These considerations imply that these tests probably do not differentiate between subjects with high and low spatial abilities as intended in certain cases. This should be kept in view especially when spatial ability tests are used for purposes like selection or career choice procedures.

In the second study with 79 students (44 females, 33 males, 2 unknown; aged 16-19, 11^{th} and 12^{th} grade) we added the JLO, which is usually used for clinical neurological assessment, to the test battery. This test examines the ability to estimate angular relationships between line segments and serves as an instrument to measure skills for recognition and processing of simple visual stimuli. We can only present preliminary results of this study yet but it points to very interesting gender specific differences in strategies used for solving spatial tests.

If we look at the test scores separated by gender we see that in case of male students almost all spatial ability scores are significantly correlated but performance in a logical reasoning test (WIT Letter Sequence subtest) is not correlated to any of them. In the female students, almost all spatial ability tests are significantly correlated both to each other and to the logical-reasoning test.

Separate factor analyses for male (Table 2) and female (Table 3) students identified two factors in both cases, however, factor loadings are different for men and women.

For men (Table 2) PSVTR, MCT, MRT, DAT, and JLO load on factor 1, which is clearly a "spatial" factor, whereas only logical reasoning loads on factor 2. For women (Table 3), PSVTR, MCT, and DAT, which are complex spatial tasks, load on factor 1, together with logical reasoning. MRT and JLO, which focus on elementary spatial functions, load on factor 2.

When logical reasoning is partialled out of the correlations among the spatial tests, the correlations in the male sample do not change much, whereas in the females, almost all correlations among spatial tests disappear. The reverse pattern shows when JLO performance is partialled out: In the male sample, all correlations among spatial tests disappear, while in the female sample, only the correlations of the MRT to the other spatial tests disappear and all correlations to logical reasoning get stronger.

These preliminary results suggest that in female students, high spatial performance is related to good reasoning skills and logical thinking, whereas for male students, speed and accuracy

of basic spatial processes are the best predictor of spatial test performance.

FUTURE WORK

Within the next few months our evaluation regarding spatial intelligence, as described in previous sections, will be conducted. In the future we plan to study general improvements of spatial ability in contrast to task specific improvements in detail. We want to seek for an answer to the question if direct manipulation as used in Construct3D and explorative interaction is sufficient to improve spatial understanding and last but not least if training of spatial intelligence in a virtual environment is more "efficient" than in a real environment.

Further, we plan to utilize Construct3D as a tool for evaluating various aspects in virtual environments in our future research. For example a comprehensive pedagogic evaluation, evaluating e.g. teaching styles or transfer of learning in educational VR/AR applications would be interesting.

ACKNOWLEDGEMENTS

The authors thank Istvan Barakonyi for his help during the evaluation studies. We thank all participants of evaluations as well as other teachers and students for testing and giving useful feedback. Part of this research was funded by the Austrian Science Fund (FWF) contract no. P14470, P16803 and Y193 and by the EU IST project Lab@Future (IST-2001-34204).

REFERENCES

[1] J. T. Bell and H. S. Fogler, "The Investigation and Application of Virtual Reality as an Educational Tool," *American Society for Engineering Education 1995 Annual Conference*, 1995.

[2] G. K. Benett, H. G. Seashore, and A. G. Wesman, "Differential Aptitude Tests, Forms S and T." New York: The Psychological Corporation, 1973.

[3] A. L. Benton, K. Hamsher, N. R. Varney, and O. Spreen, *Contributions to neurological assessment: A clinical manual*. New York: Oxford, 1983.

[4] L. N. Brown, C. J. Lahar, and J. L. Mosley, "Age and gender-related differences in strategy use for route information: A "map-present" direction-giving paradigm," *Environment and Behavior*, vol. 30, pp. 123-143, 1998.

[5] C. Byrne, "Water on Tap: The Use of Virtual Reality as an Educational Tool," University of Washington, College of Engineering, Washington 1996.

[6] J. B. Carroll, *Human cognitive abilities. A survey of factor-analytic studies*. Cambridge, UK: Cambridge University Press, 1993.

[7] CEEB College Entrance Examination Board, "Special Aptitude Test in Spatial Relations MCT," CEEB College Entrance Examination Board, 1939.

[8] R. P. Darken, T. Allard, and L. Achille, "Spatial Orientation and Wayfinding in Large-Scale Virtual Spaces: An Introduction," *Presence: Teleoperators & Virtual Environments*, vol. 7, pp. 101-107, 1998.

[9] N. Durlach, G. Allen, R. Darken, R. L. Garnett, J. Loomis, J. Templeman, and T. E. von Wiegand, "Virtual environments and the enhancement of spatial behavior: Towards a comprehensive research agenda," *PRESENCE - Teleoperators and Virtual Environments*, vol. 9, pp. 593-615, 2000.

[10] G. Gittler and J. Glück, "Differential Transfer of Learning: Effects of Instruction in Descriptive Geometry on Spatial Test Performance," *Journal of Geometry and Graphics*, vol. 2, pp. 71-84, 1998.

[11] J. Glück and S. Fitting, "Spatial strategy selection: Interesting incremental information," *International Journal of Testing*, vol. in press, 2003.

[12] R. B. Guay, "Purdue Spatial Visualization Test: Rotations," Purdue Research Foundation, West Lafayette, IN 1977.

[13] R. E. Guttman, E. Epstein, M. Amir, and L. Guttman, "A structural theory of spatial abilities," *Applied Psychological Measurement*, vol. 14, pp. 217-236, 1990.

[14] O. A. Jäger and K. Althoff, *Der WILDE-Intelligenz-Test. (WIT); e. Strukturdiagostikum; Handanweisung*. Göttingen: Hogrefe, Verlag für Psychologie, 1994.

[15] O. A. Jäger, H.-M. Süß, and A. Beauducell, "Berliner Intelligenzstruktur-Test." Göttingen: Hogrefe, Verlag für Psychologie, 1997.

[16] H. Kaufmann, "Geometry Education with Augmented Reality.," in *Ph.D. Thesis*. Vienna: Vienna University of Technology, 2004, pp. 179.
[17] H. Kaufmann and D. Schmalstieg, "Mathematics and geometry education with collaborative augmented reality," *Computers & Graphics*, vol. 27, pp. 339-345, 2003.
[18] H. Kaufmann, D. Schmalstieg, and M. Wagner, "Construct3D: a virtual reality application for mathematics and geometry education," *Education and Information Technologies*, vol. 5, pp. 263-276, 2000.
[19] M. Kozhevnikov and M. Hegarty, "A dissociation between object manipulation, spatial ability and spatial orientation ability," *Memory & Cognition*, vol. 29, pp. 745-756, 2001.
[20] J. J. LaViola Jr., "A discussion of cybersickness in virtual environments," *ACM SIGCHI Bulletin*, vol. 32, pp. 47-56, 2000.
[21] C. A. Lawton, "Gender differences in wayfinding strategies: Relationship to spatial ability and spatial strategies," *Sex Roles*, vol. 30, pp. 765-779, 1994.
[22] B. Loftin, M. Engelberg, and R. Benedetti, "Applying virtual reality in education: A prototypical virtual physics laboratory," in *Proceedings of the IEEE 1993 Symposium on Research Frontiers in Virtual Reality*. Los Alamitos, CA: IEEE Computer Society Press, 1993, pp. 67-74.
[23] D. F. Lohman, "Spatial ability: A review and reanalysis of the correlational literature," Stanford University School of Education, Aptitude Research Project, Stanford, CA Tech. Rep. No. 8, 1979.
[24] D. F. Lohman and P. C. Kyllonen, "Individual differences in solution strategy on spatial tasks," in *Individual differences in cognition*, D. F. Dillon and R. R. Schmeck, Eds. New York: Academic Press, 1983, pp. 105-135.
[25] F. Mantovani, "VR Learning: Potential and Challenges for the Use of 3D Environments in Education and Training," in *Towards CyberPsychology: Mind, Cognitions and Society in the Internet Age*, G. Riva and C. Galimberti, Eds. Amsterdam: IOS Press, 2001.
[26] J. Prümper, "Der Benutzungsfragebogen ISONORM 9241/10: Ergebnisse Zur Reliabilität und Validität," in *Software-Ergonomie '97*, R. Liskowsky, Ed. Stuttgart, 1997.
[27] C. Quaiser-Pohl and W. Lehmann, "Der Mental-Rotation-Test," Swets Test Services, Frankfurt/Main 2002.
[28] A. A. Rizzo, J. G. Buckwalter, J. S. MCGee, T. Bowerly, C. van der Zaag, U. Neumann, M. Thiebaux, L. Kim, L. Pair, and C. Chua, "Virtual environments for assessing and rehabilitating cognitive/functional performance," *Presence - Teleoperators and Virtual Environments*, vol. 10, pp. 359-374, 2001.
[29] A. A. Rizzo, J. G. Buckwalter, U. Neumann, C. Kesselman, M. Thiebaux, P. Larson, and A. Van Rooyen, "The Virtual Reality Mental Rotation Spatial Skills Project," *CyberPsychology and Behavior*, vol. 1, pp. 113-120, 1998.
[30] D. Schmalstieg, A. Fuhrmann, G. Hesina, Z. S. Szalavári, L. M. Encarnacao, M. Gervautz, and W. Purgathofer, "The Studierstube augmented reality project," *Presence - Teleoperators and Virtual Environments*, vol. 11, pp. 33-54, 2002.
[31] K.-H. Schmidt and P. Metzler, *Wortschatztest*. Weinheim: Belz, 1992.
[32] E. Souvignier, "Training räumlicher Fähigkeiten. [Training spatial abilities.]," in *Handbuch Kognitives Training*, K. J. Klauer, Ed. Göttingen: Hogrefe, 2001, pp. 293-319.
[33] H. Stumpf and J. Eliot, "A structural analysis of visual spatial ability in academically talented students," *Learning and Individual Differences*, vol. 11, pp. 137-151, 1999.
[34] G. Taxén and A. Naeve, "CyberMath: Exploring Open Issues in VR-Based Learning," *SIGGRAPH 2001 Educators Program*, vol. SIGGRAPH 2001 Conference Abstracts and Applications, pp. 49-51, 2001.
[35] F. Tendick, M. Downes, T. Goktekin, M. C. Cavusoglu, D. Feygin, X. Wu, R. Eyal, M. Hegarty, and L. W. Way, "A Virtual Environment Testbed for Training Laparoscopic Surgical Skills," *Presence*, vol. 9, pp. 236-255, 2000.
[36] S. G. Vandenberg and A. R. Kuse, "Mental Rotations: a group test of three-dimensional spatial visualization," *Perceptual and Motor Skills*, vol. 47, pp. 599-604, 1978.

Contact

Hannes Kaufmann
Institute of Software Technology and Interactive Systems
Vienna University of Technology
Favoritenstr. 9-11/188-2,
A-1040 Vienna, Austria
Email: kaufmann@ims.tuwien.ac.at

The Gedanken Experiment of Human Dynamics

Y. Cai[1] and J. Klein-Seetharaman[1,2]

[1]CyLab, Carnegie Mellon University, Pittsburgh
[2] Department of Pharmacology, University of Pittsburgh Medical School, Pittsburgh

Abstract: *Understanding human dynamics is an important step in clinical therapies, such as blood glucose management or weight control. It requires insight into the complex interactions between the components of biomedical systems. This is challenging because of the enormous amount of data and knowledge in this domain. Gedanken Experiment is an intuitive, qualitative thinking process, which have been used by physicists for decades. Our goal is to enable an interactive game-like environment for users with any background, while remaining sufficiently flexible to target medical problems at a level of abstraction, from the conformational changes of a protein to the interaction of the various biochemical pathways in our body. Here, we present an interactive and visual problem-solving environment for the biomedical domain. We designed a biological world model, in which users can explore biological interactions by role-playing "characters" such as cells and molecules or as an observer in a "shielded vessel", both with the option of networked collaboration between simultaneous users. The system architecture of these "characters" contains four main components:[1] Bio-behavior is modeled using cellular automata.[2] Bio-morphing uses vision-based shape tracking techniques to learn from recordings of real biological dynamics.[3] Bio-sensing is based on molecular principles of recognition to identify objects, environmental conditions and progression in a process.[4] Bio-dynamics implements mathematical models of cell growth and fluid-dynamic properties of biological solutions. The principles are implemented in a simple world model of the human vascular system and a biomedical problem that involves an infection by Neisseria meningitides where the biological characters are white and red blood cells and Neisseria cells. Our case studies show that the system can be used for public health education, biomedical simulation and creative problem solving.*

INTRODUCTION

Understanding human dynamics is an important step in clinical therapies, such as blood glucose management or weight control. It requires insight into the complex interactions between the components of biomedical systems. This is challenging because of the enormous amount of data and knowledge in this domain. Gedanken Experiment (GE) is an intuitive, qualitative thinking process, which have been used by physicists for decades. Novel approaches are being developed, for example a storytelling system has been presented to fertilize multidisciplinary biomedical problem solving.[5] Furthermore, modern biomedical education makes extensive use of visualization of biomedical processes and concepts, for example the publication of the human genome sequence was accompanied by a CD-ROM that presented genome background as well as DNA sequencing techniques in animations.[6] However, these visualization tools are mostly designed to complement traditional teaching techniques and are not very interactive. More interaction is provided in the "Virtual Cell", a virtual environment in which question-based assignments are given to users in a simulated laboratory.[7] A submarine is launched that immerses the user in the virtual environment of the cell populated by sub-cellular components which the user can investigate. With a toolbox, various cellular processes can be investigated experimentally. The results of these investigations and experimentations allow users to solve the assignments at their own pace and through their own motivation. It was shown that this approach significantly improves authentic learning, in particular for large enrollment general biology classes.[8] At the other end of the spectrum, realistic, fully interactive virtual laboratories have been developed to simulate chemical,[9] biomedical,[10] and recently nanoscience[11] laboratory experiments. However, in their present form, these systems were not designed to be integrated GEs because they are targeted to students and researchers

for solving very specific problems and therefore contain a large amount of domain specific information. Inexperienced users will not have sufficient insight needed for discovery and solving problems. Insight, i.e. the capability to make non-obvious connections between the complex interactions of the components of these systems, is the main requirement for solving biomedical problems.[12] Such insightful solutions can often be found in an interactive and visual PSE, as demonstrated for example by the fact that despite the modern numerical computing technologies, biophysicists today still use Gedanken experiments for concept development.[13] Although there are many virtual reality three-dimensional molecular models available, biochemists still use hand-made models for intuitive reasoning. It is striking that simple intuitive simulation is still one of the most powerful approaches to creative problem solving.

Since the early days of artificial intelligence, issues of modeling scientific reasoning and its representation, in particular for those connected with everyday knowledge of the behavior of the physical world, have been studied.[14] At least two aspects have been explored: multiple representation and qualitative reasoning. Computation with Multiple Representations (CaMeRa) is a model that simulates human problem solving with multiple representations, including pictures and words.[15] CaMeRa combines a parallel network, used to process the low-level pictorial information, with rule-based processes in higher-level pictorial and verbal reasoning. Furthermore, many AI systems have been developed to simulate the cognition about physical and biological knowledge. What will happen if we spill a glass of milk on the floor? For humans, the answer is common sense, but understanding this process is non-trivial for computers. To arrive at an exact solution, the computer has to solve a set of non-linear partial differential equations of hydrodynamics that are computationally intractable even for simple boundary conditions.[16] A few studies have focused on the qualitative simulation of physical phenomena. Thus, Gardin uses two-dimensional diagrams to represent physical objects and their interaction[17] and Forbus uses the fuzzy language of "qualitative physics" to model the physical variables.[18] Lower-resolution qualitative models have made significant impact in many fields, including biology. A typical example is the Game of Life, a "Cellular Automaton."[19] A cellular automaton is an array of identically programmed automata, or "cells", which interact with one another. The state of each cell changes from one generation to the next depending on the state of its immediate neighbors. By building appropriate rules, complex behavior can be simulated, ranging from the motion of fluids to outbreaks of starfish on a coral reef. Even if the line of cells starts with a random arrangement of states, the rules force patterns to emerge in life-like behavior. Empirical studies by Steven Wolfram[20] and others show that even the simple linear automata behave in ways reminiscent of complex biological systems. In light of this discovery, we intend to use simple biological characters to generate dynamic interactions.

Creative Problem Solving Environments have been studied mainly in the management science area. Most recent studies focus on collaborative creativity, stimulus culture, and information flow. For example, "brainstorming" has been viewed as a panacea in corporations since IDEO has promoted the methodology.[21] John Kao's "Jamming" theory[22] uses a jazz jam session as a metaphor to address how to stimulate employees at work. Steven Eppinger's Design Information Matrix[23] focuses on representing information flows rather than task flows. According to Constructionism, people do not simply "get an idea"; they construct it. Within the framework of the recently developed "Idea Flow" theory to address the dynamics of creative problem solving,[24] it was shown that the bidirectional idea flow is the most efficient interaction pattern in innovation. Feedback can enhance the flow both in terms of effectiveness and efficiency. Multiphysics simulation and knowledge-based innovation heuristics build the bridge between the innovative idea and reality, which will eventually change the landscape of scientific discovery. Open source, open system architecture and virtual communities bring idea flows from the outside. This is the trend of contemporary scientific discovery and system design that not only creates just a product but an inspiration for interaction.

Here we present a computer game as a novel environment for biological problem solving, where it provides a real-time interactive platform

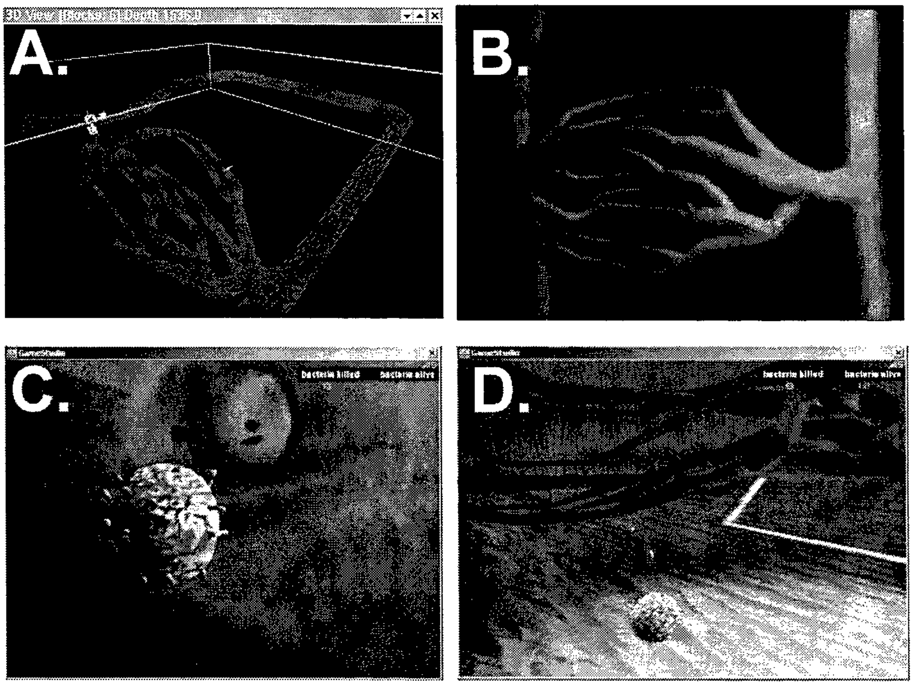


Figure 1. *World model and biological characters implemented in the game.* A. Wireframe model of the vascular system world model. B. 3-D photorealistic model showing arteries and capillaries. C. The Macrophage (white blood cell) is inside the blood stream with red blood cells. D. After actively moving out of the blood stream, the macrophage approaches bacteria that infected human body tissue.

for users. The goal of this study is to develop a game-based PSE for users to explore multimodal interactions inside a biological system. It includes essential biological simulation models for the immune system and the blood system. It allows users to manipulate and to participate in the interactions among the components of the system. The biological characters are simulated by software agents.

PROTOTYPE

As a test bed for the development of a game-based Gedanken experiment system for biomedical science, we designed a scientific problem that is derived from our ongoing research projects. By applying computational language technologies to the large amounts of whole genome sequence data publicly available, we have identified "genome signatures" that may provide novel approaches to the development of vaccines against pathogenic microorganisms such as Neisseria.[25] The biomedical problem to be explored here is to find treatment for fatal meningitis. The new idea for the biomedical simulator is to develop an interactive interface modeled after traditional game engines that teaches users without background in biology the understanding of this research problem ranging in hierarchy from atomic to macroscopic scales (Fig. 1). In this hierarchy, the macroscopic level is that of infection of a human body with Neisseria. Fighting the infection requires a molecular level understanding of the processes involved. The goal is to provide the user with the necessary insight to creatively generate and test possible approaches to solving this problem using the simulator.

BioSim version 1.0 is a rapid prototype for this system. It is a two-stage game that simulates the journey of red blood cells and white blood cells (macrophages). The goal is to introduce the basic concepts of cellular interaction and the human immune system. The game begins with an animated scene of a blood stream with red and white cells moving passively with the heartbeat. Using a mouse and the arrow keys, the player can take the role of a biological character, for example a macrophage, and navigate

inside the blood stream. The user can actively move to tissue that is infected by bacterial cells, which multiply at a certain speed. Screen shots of these processes are shown in Fig. 2.

BioSim 1.0 is implemented on PC. Photorealistic 3D models of components of the system were created with 3D Studio Max and exported to Game Studio 3D (an example is shown in Fig. 3). The 3D Modeler of GameStudio 3D was used to create the game scenes, biomorphed characters and the integration of the world/ character dynamics and interactions. C-script, a C-style language, was used to encode the bio-dynamics and bio-sensing behaviors. Game Studio is run under the Windows operation system. It provides capability for either single user or multiple users across the Internet.

BIOLOGICAL "WORLD MODEL"

In game design, "world models" are similar to the theatre stage or film scene with which actors and characters interact. A world model is often static and large in size. In this project, we developed a comprehensive world model that includes the vascular system with artery, veins and capillaries, as well as tissues (Fig. 1 A,B). In this world, the user can fly, walk or run through as one of the biological characters (Fig. 1 C,D). In the prototype BioSim 1.0, we have developed two scenes: inside and outside of the capillary. The transition of the scenes is possible by "squeezing" a character actively from the blood stream to the tissue in the capillary regions.

BIOLOGICAL CHARACTERS

We have defined the following 3D animated characters that simulate biological behavior: bacteria, macrophages, and red blood cells. To define interactions among characters and between the characters and the world model, we use collision detection (section 2.4.3 below). For the stand-alone characters, we apply bio-morphing to assign key frames to them (section 2.4.2 below). Bio-morphing is accomplished by digitizing deformed shapes from microscopic images of organisms, building wire frames and attaching texture and color skins.

SYSTEM ARCHITECTURE

The PSE contains three interaction modes: role-play, voyage and networked problem solving.

Role-Play. The system allows the user to be a biological character in the game. Cognition Science shows that role-play is an important way to stimulate creative ideas. It enables the user to have an intimate connection to the character. Also, personalization of a biological character makes a game more interactive.

Voyage. The user can navigate through the biological system in the game, either as a character, or using a 'ship', supporting different view angles, e.g. traveling through capillaries and tissues. Voyage allows exploration at the user's chosen leisure, accommodating users with various backgrounds.

Distributed Problem Solving. The game engine allows users to play the game over the Internet so that large problems can be solved collaboratively or antagonistically, e.g. some users can play macrophages and others can play bacteria. The distributed problem solving enables diverse game strategies and more excitement of the game. The user can also choose between two aims, rather than playing the role of a single biological component only. The user can assume the roles of multiple biological characters, thus studying their individual influence on a particular aim. These aims are to induce an infection with Neisseria and ensure its successful propagation in the human body or to fight the Neisseria infection.

BIOLOGICAL CHARACTER LIBRARY

A biological character is defined as an entity that includes functions, forms, behaviors and interfaces. For example, some of the functions of a macrophage are to locate and destroy bacteria (see below), while the function of a bacterium is to divide and spread. A given character has a sequence of forms in correspondence to its dynamic behaviors. An interface to interact with other entities or the environment is designed.

Example Macrophage:
Functions = locate bacteria | destroy bacteria

Behaviors = walk | eat | shrink | kill | die
Forms (key-frame sequences) = moving | search | squeeze | killing | death
Interfaces = collision | chemotaxis (sensing) | tactile (sensing)

The principles describing behaviors, forms and interfaces that are common to all characters are described below.

Behavior. Interaction is the key to computer games, and we believe also to an efficient bio-medical PSE. We therefore allow the user to control the behavior of biological characters by realistic and scientifically accurate bio-interactions. The transitions of each character are represented by a state machine (Fig. 4A). For example a macrophage's states include the transitions to deform, shrink, eat, walk and die. Each behavior is defined by a set of forms (see section 2.4.2 below). We simulate biological processes and character behavior ("bio-dynamics") realistically. For each character, we define its interactive modes, such as motion, reproduction and death. Taking bacteria for example, we use the following rules (Fig. 4B):

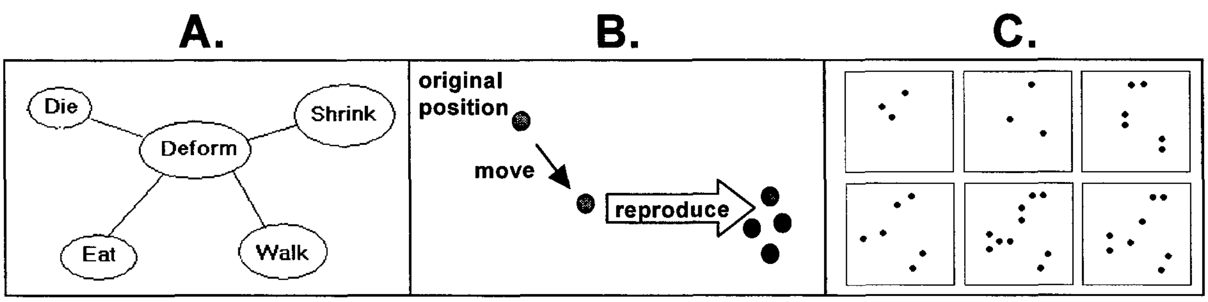


Figure 2 *Examples for Character Dynamics.* A. State machine for a macrophage. B. Dynamics of an organism modeled by Cellular Automata. C. Example for the time-evolution of bacterial growth and spatial distribution.

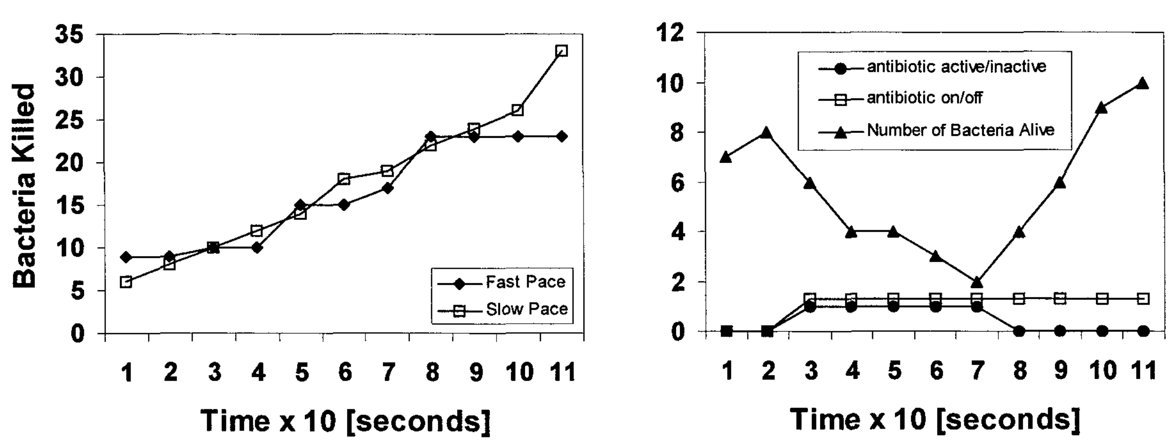


Figure 3. Strategies against bacterial infection that can be explored in the game, speed of macrophage movement (left) and use of antibiotics (right). The fast pace strategy often leads to missing targets. The slow pace strategy gains steady capture rate. The use of antibiotics can be limited by gradual development of bacterial resistance. At that point, administration of drug does not inhibit bacterial growth.

Autonomous motion. Given a fixed duration, each bacterium moves a distance x at angle y, where x and y are random values. The distance should not exceed the maximal distance.

Reproduction. Given a predefined duration, each bacterium reproduces a copy of its own which is placed beside its original position.

The *Logistic growth model*[26] adequately describes the reproduction process of simple organisms over limited time periods by equation (1), where M is the carrying capacity of the population B at time n with growth rate r.

$$B_{n+1} = B_n + rB_n(1 - B_n/M)\,. \qquad (1)$$

Death. If a bacterium's life cycle is over or if other cells eat it, it is removed from the scene.

PROBLEM SOLVING WITH BIOSIM

SUPPORTING STRATEGIC THINKING IN USERS

We conducted experiments in the effectiveness of the game to raise an awareness of the important issues in biomedical research on users with no background. The ideal group at this stage of implementation of the game is young children, for two reasons. One, children are unbiased and without background. Second, children learn optimally when the material to be learned is presented to them in an accurate way to avoid the build-up of incorrect models by implicit learning.[27] Implicit learning of correct biomedical concepts by children therefore requires the same fundamental issue of scientific accuracy as other users will require once the game reaches the stage of providing a PSE for users with any background. We tested BioSim 1.0 on 14 children at KinderCare, Cranberry, PA, on August 9th, 2002 and February 25, 2003. We let four- and five-year-old children play with the game on a laptop and focused our attention on strategic aspects and active questioning.

Two strategies were quantified, the speed of macrophage movement towards the bacteria (Fig. 3, left) and the use of antibiotics in aiding the killing of the bacteria (Fig. 3, right). All children learnt quickly to shift from fast pace chasing to slow pace chasing so that their capture rate was improved. We then tested a more challenging concept, that of usage of antibiotics to aid the killing of the bacteria. We included the ability of bacteria to develop resistance in our growth model. Thus, the children had to discover that antibiotics at some stage in the game no longer inhibit bacterial growth. This was only observed by a single 5-year old, all other children kept on administering antibiotics despite energy consumption and lack of effect (Fig. 8, right). These types of quantitative assessment of strategic behavior of users open novel ways to analyze learning of problem solving skills that would not be possible with conventional teaching methods.

SUPPORTING CREATIVE THINKING IN USERS

To assess learning in children, we asked questions such as "How does the macrophage get out of the capillary?" or "How do you kill bacteria?" The children used intuitive metaphors, for example the analogy of "vacuum" and "crash into" to describe how the macrophage attacks bacteria. This shows that the players are very sensitive to the intimate design details of the game, which opens a window for game devel-

Observation	4-year old	5-year old
Asked relevant questions	0	4
Controlled the game successfully	2	5
Described bacterial growth behavior	1	5
Described macrophage behavior	2	6

Table 1. Comparison of the reactions of two groups of children to the game. The children in the first group were 4 years old, those in the other were 5 years old. Each group consisted of 7 children, and the total number of children tested was 14.

opers to *encode* very subtle knowledge about complex biological interactions. Finally, we tested the game-induced stimulation of questioning and creative thinking in the children. The results are summarized in Table 1. The five-year-old children asked several meaningful questions, for example: "Are bacteria germs?" "Where do the white cells go?" "What's a red cell?" "Where do the bacteria live?" "Is the macrophage good or bad?" Overall, four-year-old children asked fewer questions, and most of their questions were not relevant, for example, "Do you have other games?" "I don't want my head eaten off." These observations suggest that there may be a turning point between ages 4 and 5 where a PSE can become effective.

SUMMARY

Future biomedical problem solving is beyond traditional means because of the existing challenges in cross-disciplinary communication and interpretation and utilization of vast quantities of available biomedical data. We want to build a virtual PSE that combines advanced computer graphics, computer vision, artificial intelligence technologies and creative instruction technologies. In this PSE, cross-disciplinary education will be on-demand, entertaining and interactive. This will allow focus on discovery and creativity rather than one-way tutoring. Towards this long-term goal, here, we have presented a game-based PSE, where users can explore complex biological interactions with navigation, role-play, and networked collaboration. The study investigates the system architecture of the biological game, bio-morphing characters, and bio-interactions with bio-sensing and bio-dynamics. The game is based on realistic biological models, such as logistic growth models of simple organism reproduction and immigration models of cell movements. The prototype has been implemented on PC and tested in a preschool environment where users have little knowledge in biology. The experiment shows that the game greatly inspired users both in concept learning and entertainment. It supports strategic thinking, creative thinking, as well as professional innovative problem solving. Our study suggests that the game-based PSE helps users to learn bio-system dynamics and multiple object interactions.

ACKNOWLEDGMENTS

This work was supported by the Alexander von Humboldt-Foundation and Zukunftsinvestitionsprogramm der Bundesregierung, Germany.

REFERENCES

Altshuller, G., The Innovation Algorithm. 2000: Technical Innovation Center.

Sullivan, J.A., Chemotaxis of Human Neutrophils: Charlottesville, VA, USA. p. 8 min.

Kass, M., A.P. Witkin, and D. Terzopoulos, Snakes: Active Contour Models. Int. J. Computer Vision, 1988. 1(4): p. 321-331.

Roco, M.C. and W.S. Bainbridge, Overview: Converging Technologies for Improving Human Performance: Nanotechnology, Biotechnology, Information Technology, and Cognitive Science (NBIC), in Converging Technologies for Improving Human Performance, M.C. Roco and W.S. Bainbridge, Editors. 2002, Kluwer Academic Publishers: Arlington. p. 1-23.

Kuchinsky, A., K. Graham, D. Moh, A. Adler, K. Babaria, and M.L. Creech. Biological Storytelling: A Software Tool for Biological Information Organization Based Upon Narrative Structure. in AVI. 2002.

www.sciencemag.org.

White, A.R., P.E. McClean, and B.M. Slator. The Virtual Cell: An Interactive, Virtual Environment for Cell Biology. in Wold Conference on Educational Media, Hypermedia and Telecommunications. 1999. Seattle, WA.

McClean, P.E., B. Saini-Eidukat, D. Schwert, B.M. Slator, and A.R. White. Virtual Worlds in Large Enrollment Science Classes Significantly Improve Authentic Learning. in 12th Intl. Conf. on College Teaching and Learning. 2001. Jacksonville, FL: Center for the Advancement of Teaching and Learning.

ir.chem.cmu.edu/irproject/applets/virtuallab/.

http://www.biointeractive.org/.

Guggisberg, M., P. Fornaro, T. Gyalog, and H. Burkhart, An Interdisciplinary Virtual Laboratory on Nanoscience. Future Generation Computer Systems, 2003. 19: p. 133-141.

Cai, Y., Pictorial Thinking. Journal of Cognition Science, 1986.

Hayden, T., The Inner Einstein, in *US News*. 2002.

McCarthy, J. and P.J. Hayes, Some Philosophical Problems from the Standpoint of Artificial Intelligence, in Machine Intelligence, D. Michie, Editor. 1969, Edinburgh University Press: Edinburgh.
Simon, H., Models of Thought. Vol. II. 1989, Yale: Yale Press.
Feynman, R., The Feynman Lectures on Physics. 1963, Reading, Massachusetts: Addison-Wesley.
Gardin, F. and B. Meltzer, Analogical Representations of Naive Physics. Artificial Intelligence, 1989. 38: p. 139-159.
Forbus, K.D., Qualitative Process Theory. Artificial Intelligence, 1994. 24: p. 85-168.
Gardner, M., Mathematical Games: The Fantastic Combinations of John Conway's New Solitaire Game "Life". Scientific American, 1970. 223: p. 120-123.
Wolfram, S., A New Kind of Science. 2002: Wolfram Publishing.
Schrage, M., Serious Play: How the World's Best Companies Simulate to Innovate. 2000, Boston: Harvard Business School Press.
Kao, J., Jamming. 1997: HarperBusiness.
Eppinger, S.D., Innovation at the Speed of Information. Harvard Business Review, 2001. 79 (1): p. 149-158.
Cai, Y. Idea Flow. in International Conf. of Design and Management. 2001. Boston.
Ganapathiraju, M., D. Weisser, R. Rosenfeld, J. Carbonell, R. Reddy, and J. Klein-Seetharaman. Comparative N-Gram Analysis of Whole-Genome Protein Sequences. in Human Language Technologies. 2002. San Diego.
Guyton, A.C. and J.E. Hall, Textbook of Medical Physiology. 1997, Philadelphia: W.B. Saunders Co.
Perrig, P. and W.J. Perrig, Implicit and Explicit Memory in Mentally Retarded, Learning Disabled, and Normal Children. Swiss J. of Psychology, 1995. 54(2): p. 77-86.

Contact

Yang Cai
Carnegie Mellon University
Email: ycai@cmu.edu

The Recording of Observational Behaviors in Virtual Immersion: A New Research and Clinical Tool to Address the Problem of Sexual Preferences with Paraphiliacs

P. Renaud, Ph.D.[1], J. Proulx, Ph.D.[2], J. L. Rouleau, Ph.D.[3], S. Bouchard, Ph.D.[1], G. Madrigrano, Ph.D[4]., J. Bradford, M.D.[4], P. Fedoroff, M.D.[4]

[1] Laboratoire de cyberpsychologie, Département de psychoéducation et de psychologie, Université du Québec en Outaouais, Institut Philippe-Pinel de Montréal
[2]Département de criminologie, Université de Montréal,
[3]Département de psychologie, Université de Montréal,
[4]Forensic Program, Royal Ottawa Hospital

Abstract: *A new method to assess and treat deviant sexual preferences based on the combined usage of virtual reality, eye-tracking devices and penile plethysmography is presented. This method tries to answer some of the shortcomings undermining current methods used in research and clinical practice of forensic psychology and rehabilitation. Among these shortcomings, threats to internal validity caused by non compliance and faking normal sexual responses are the most important ones. The victimization of actual photographed models (adults and children) to prompt sexual arousal is also ethically problematic. Hence the use of sexual avatars depicting various age periods and secondary sexual characteristics. These are used to elicit oculomotor behaviors and physiological responses expressing esthetic interest, approach and genital responses which are continuously monitored via video-oculography and penile plethysmography. Preliminary results of the avatars' validation process are also presented.*

THEORETICAL BACKGROUND

It is on sexual preference assessment's premises that an effective treatment of sexual deviancy relies first. Sexual preferences are usually assessed either by resorting on sexual responses recorded with a penile plethysmograph or by using visual reaction time from stimuli with sexual content[1,2,5,7,9,16,25]. However, numerous shortcomings come with penile plethysmography and visual reaction time, and most notably not conscientiously paying attention to stimuli and/or exerting a misleading voluntary erectile control, which are important threats to the internal validity of these assessment procedures (do not forget that these patients are generally not eager for being assessed for such reasons, and in such ways[6,13,14].The victimization of children is another major weakness with assessment procedures using pictures of real children, either to arouse deviant sexual response or deviant interest as indexed by visual reaction time.

In order to get round these limitations, we developed a method that controls gazing activity relative to sexual avatars. We had already used a similar logic in the past to assess behavioral avoidance with arachnophobics[20] and to assess sexual preferences with normal subjects[23].This method counts on the possibility to literally get inside a patient's subjective viewpoint by simultaneously considering the momentary scene displayed to him in virtual immersion as well as his punctual oculomotor activities, as these latter largely contribute to the content of his attentional focus (Figure 1; [18,24,21,22]). Coupling this new method with classic penile plethysmography allows indeed, *prima facie*, a far better internal validity to sexual preference assessment, considering the aforementioned first two shortcomings inherent to classic methods.

Regarding the stimulus part peculiar to this new assessment method, avatars depicting naked characters of both genders and of clinically significant age phases are required to prompt sexual attraction and arousal. It is usually theorized that sexual attraction and arousal sequentially unfold with the aesthetic, the approach and the genital responses[7,18,24]. As a major asset, the resort to these synthetic characters guards against the victimization of real models that are used with classic methods[18].

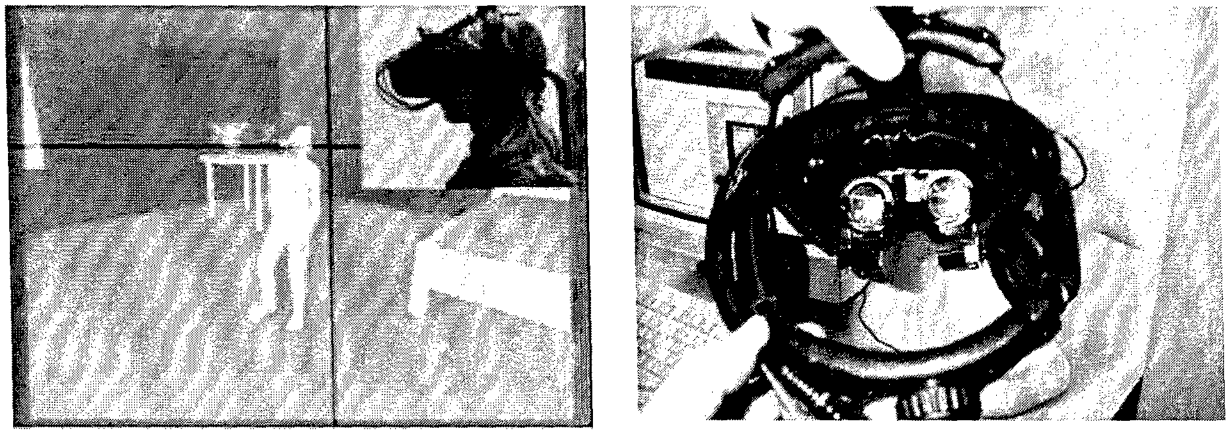


Figure 1. Inside the patient's vantage point of view; the crosshair depicts the momentary point of regard of the immersed subject shown in the upper right corner photo; the avatar personifies a female child of 8 years old; on the right hand side, a photo of the monocular infrared eye-tracking system combined within the binocular HMD

METHODS

In a more technical fashion, our method relies upon a technological setting including what is usually necessary to present virtual environments in immersion plus equipments dedicated to eye-movement tracking from within a Virtual Research V8 head mounted display (HMD). A special mounting built from an ASL monocular infrared eye-tracking system combined within the binocular HMD is used to track eye-movements in immersion (see figure1). Head-movements are recorded from an Intersense IS-900 tracking system rendering the 6 degrees-of-freedom (DOF) of translation and rotation.

Our method performs gaze analysis by the way of virtual measurement points (VMP) placed over virtual objects for the analysis of eye-movements in relation to specific features of these objects. These VMPs are placed over meaningful areas such as the simulated erogenous zones depicted over an avatar. Gaze radial angular deviation (GRAD) from a VMP is given by the combination of the 6 DOF developed by head-movements and the 2 DOF (*x* and *y* coordinates) rendered by the eye-tracking system[21-22].

While variations in the 6 DOF developed by head-movements define momentary changes in the global scene presented through the HMD, the 2 DOF given by the eye-tracking device allow the computation of the line of sight's positioning relative to VMPs (Figure 1 and 3). The closer this measure gets to zero, the closer the gaze dwells in the vicinity of the selected VMP. Moreover, VMPs are locked onto virtual objects and move jointly with them which allows analysis of visual pursuit with dynamic virtual objects.

As other measurements ensuing from this method, the subject's distance from the VMPs (which is a reliable index of social proxemics; figure 5), the pupil size diameter (which may be indicative of preferences) and the blinking response (which is a good index of a defensive state) are also obtainable[27-28].

These oculomotor measures are sampled in synchronicity with the erectile response which is recorded from a Limestone technology penile plethysmograph. The erectile response in question is expressed as the penile circumference recorded from the stretching a strain gauge placed around the penis of the assessee while he is in immersion with a sexual avatar (Figures 1 and 4).

Another version of this system works with a standard computer flat screen combined with a pan-tilt mobile infrared camera installed below. This mobile infrared camera, fine-tuned by a head-tracking system (IS-900 from Intersense), captures the assessed individual's eye movements. However, with this particular version of the system, the assessee's inherent tridimen-

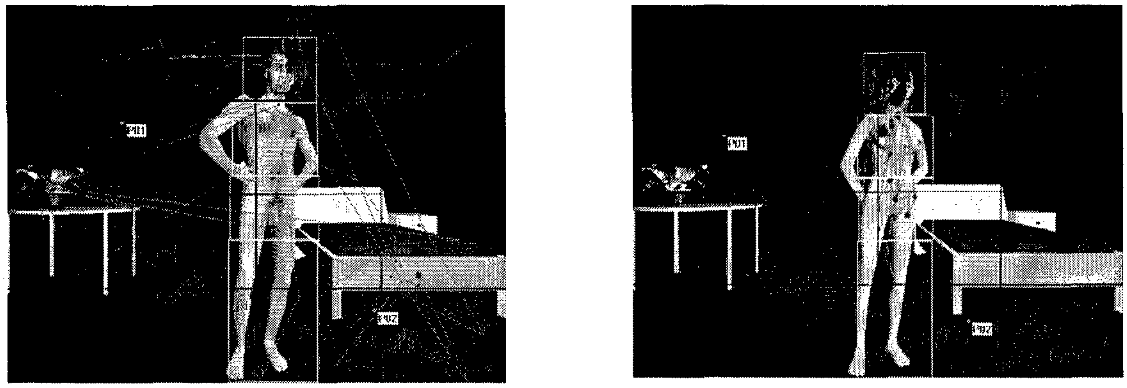


Figure 2 Ocular saccades (lines) and fixations (dots) patterns as superimposed over a male adult avatar (right) and a female adult avatar (left); 2 minutes data sampling coming from one male heterosexual subject.

sional visual perspective is not grasped as such like with full immersive video-oculography as described above. With this pan-tilt mobile infrared camera method, measurements are limited to the recording of eye movements as expressed by ocular saccades and fixations mapped over a 2D plane. Saccades are the most common eye movements, they involve rapid jumps of the eyes from one position to another while fixation, i.e. the steady gaze holding over stationary objects, can be considered as a special case of visual pursuit in which the target is at zero velocity; fixation time ranges from 150ms to 600ms with an average of 300ms; jumps observed in major saccadic eye movements are usually larger than 1.2 degree[28]. Figure 2 presents two examples of ocular saccades (lines) and fixations (dots) patterns as superimposed over a male adult avatar (right) and a female adult avatar (left).

The virtual stimuli that we use to prompt sexual attraction and arousal are animated naked avatars. These have been designed, developed and validated in order to make sure that they would be perceived as representing the required sexual properties to assess sexual preference with pedophile patients[23,18]. Other paraphilias will of course require the development of other specific virtual environments and avatars. See section 3 for statistical results.

You can get access to online video and Power point documents presenting this method as well as the avatars that we developed (http:// w3.uqo.ca/cyberpsy/atsa2004vid.avi; http:// w3.uqo.ca/cyberpsy/atsa2004pdf.pdf; [18].

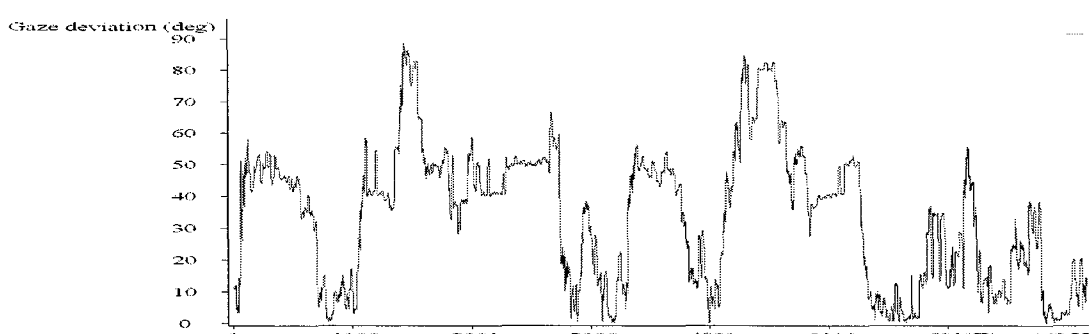


Figure 3. Gazing response as expressed in angular deviation from a virtual measurement point (VMP) marking out the avatar's head; 2 minutes data sampling coming from one subject (expressed in degree).

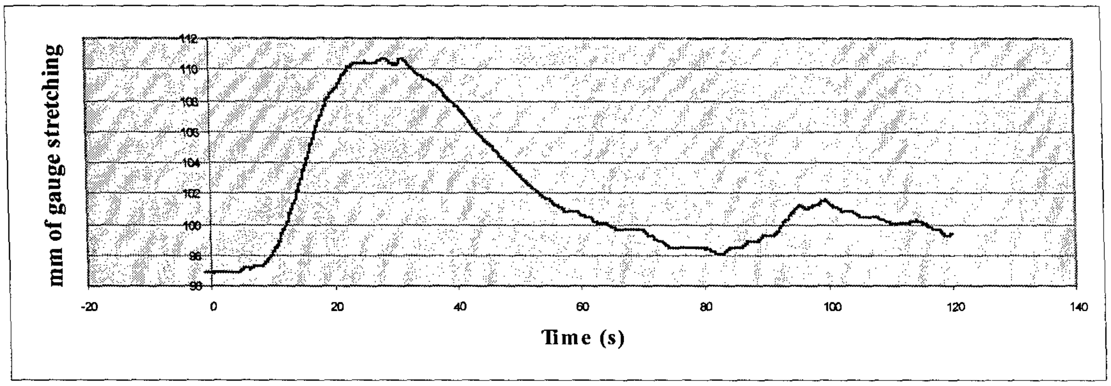


Figure 4. Erectile response as expressed in millimeters of penile gauge stretching, in function of time; 2 minutes data sampling coming from one subject.

ASSESSMENT OF THE AVATARS' PERCEIVED AGE AND LEVEL OF REALISM

As mentioned in section 2, the avatars the we use have been designed, developed and validated in order to make sure that they would be perceived as representing the required sexual properties and the required age to assess sexual preference with pedophile patients. We also developed a sexually neutral avatar for control purposes; all avatars are animated in a similar fashion, that is following the same general way but with slight adaptations to fit each age period and gender behavioural properties. Figure 5 presents snapshot images of the seven categories of avatars, male and female adults, male and female adolescents and male and female children, and the sexually neutral avatar. These were developed to respectively emulate the following age periods : between 25 and 35 years old for the adult, between 13 and 17 years old for the adolescent, and between 6 and 10 years old for the children. All prototypes (except the sexually neutral) were presented to a sample a 63 subjects, 20 males and 43 females, that had to estimate their age and level of realism (Question: *On a scale ranging from 1 to 7, to what extent do you consider this character realistic?*). Descriptive statistics for the age and level of realism results are displayed respectively in table 1 and 2.

Repeated measures analyses of variance and pairwise comparisons confirmed that avatars are perceived as representing members of distinct age groups (adults, adolescents and chlidren), with slight differences between pairs in each group ($\underline{F}(5,58)=383.27$, $p<.0001$): for

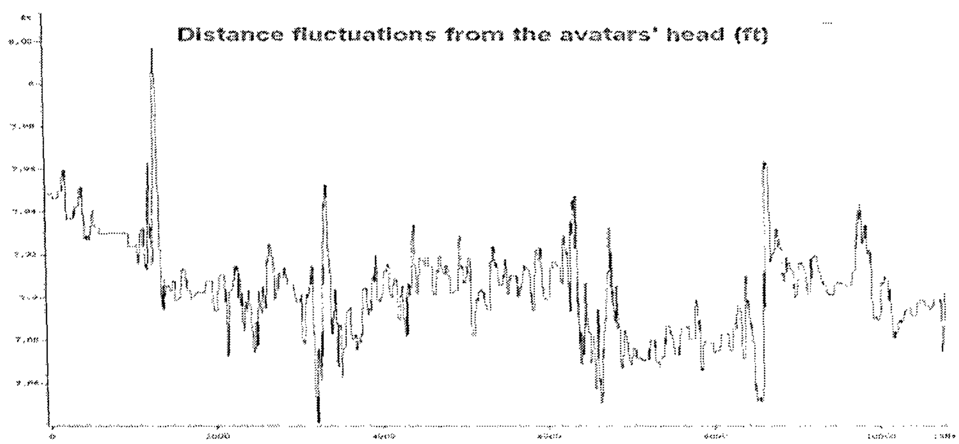


Figure 5. Measures of social proxemics: distance fluctuations from one of the VMP edited over the avatar's head; 2 minutes data sampling coming from one subject (expressed in feet).

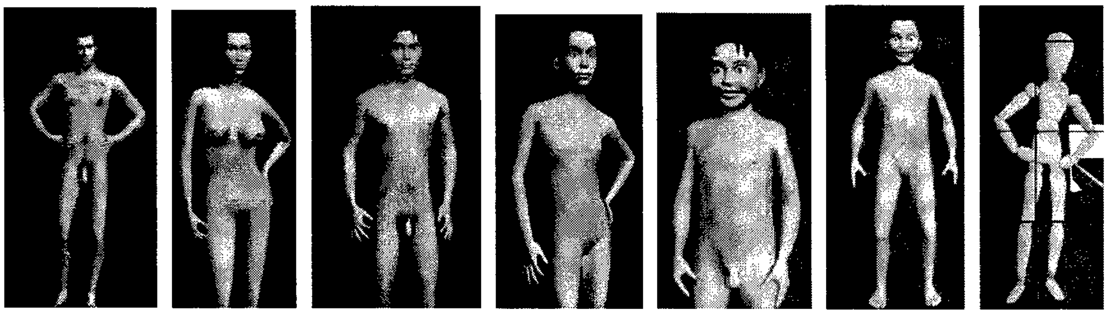


Figure 5. Snapshot images of the avatars' prototypes: male and female adults, male and female adolescents, male and female children and a sexually neutral avatar for control purposes.

instance, the male adult avatar is perceived as 1.9 years older than the adult female avatar and the male child avatar is perceived as 0.635 year older than the female child avatar. The same kind of analyses also confirmed that the overall level of realism is acceptable and would need improvements ($\underline{F}(5,58)=16.251$, $p<.0001$). We also found differences between categories: the adolescent avatars are perceived as the least realistic of all, and even more so for the female adolescent avatar, the male adult avatar is perceived as slightly more realistic than the female adult avatar and the children avatars are perceived as the most realistic, tied with the male adult avatar. These results will guide further improvements of these stimuli.

APPLICATIONS

First, the method put forward in this paper is about controlling the attentional content of the assessee through the minute examination of his observational behavior. To know if the assessee's eyes are open or not is the very first requisite that our method answers to. To pinpoint the gaze location relatively to the morphological layout of sexual avatars is a second crucial aspect of the method that can significantly increase the internal validity of the sexual preference assessment procedure based on penile plethysmography. By knowing how and when the assessee avoids visual contact with the avatar's features being able to arouse his sexual interest, approach and genital responses,

Avatars (gender and age): Perceived age	Min value	Max value	Average	SD
Age Male adult	15.00	40.00	26.5714	5.27842
Age Female adult	16.00	36.00	24.6508	3.98853
Age Male adolescent	10.00	30.00	14.5397	3.35446
Age Female adolescent	9.00	40.00	14.4286	4.47831
Age Male Child	4.00	9.00	6.8413	1.23401
Age Female Child	4.00	9.00	6.2063	1.23339

Table 1. Descriptive statistics for the avatars perceived age (N=63).

Avatars (gender and age):	Min value	Max value	Average	SD
M adult	3.00	7.00	4.7619	1.16001
F adult	2.00	7.00	4.5238	1.30578
M adolescent	2.00	7.00	4.1746	1.39746
F adolescent	1.00	6.00	3.5873	1.32756
M child	2.00	7.00	4.8889	1.24578
F child	2.00	7.00	4.8730	1.15692

Table 2. Descriptive statistics for the avatars estimated level of realism on a scale ranging from 1 to 7 (N=63).

the internal validity of the erectile response measurement is indeed boosted.

Secondly, this method is also about the possibility to develop an original index of sexual preference whose basis would be visual scanpath's parameters in themselves. Preliminary results tend to incline toward the relative time spent on and off the sexually prompting areas displayed on the avatars (as tagged by the VMPs), as well as the gaze moving sequence from one area to another, as good candidates to diagnose properly sexual attraction, deviant or not[23,18]. The inherently dynamic properties of the oculomotor signal, that is how this latter fluctuates in time, its velocity, acceleration or dynamic properties of higher level, could also be indicative of sexual interests[21,22-18]. The latter measurement potentials could be combined as well with measures of proxemics, pupillometrics and ocular defensive response to yield a composite index of sexual preference.

Mediated biofeedback and operant conditioning of sexual behavior and perception

Sexual deviation is treated in various ways but mainstream therapies for paraphilias rely essentially on cognitive-behavioral techniques notably with the use of aversive therapy and covert sensitization to alter deviant sexual arousal, behavior and interest[8]. Penile biofeedback, with and without signaled punishment, has also been tried with interesting results to help sex offenders gain control over their deviant behaviors[15,8].

Classically, feedback stimuli in biofeedback have been mostly audio or visual signals sent continuously and monotonously in proportion to physiological parameters (e.g. amplitude and frequency[3,27]). More recently however, biofeedback applications have been used through video games and virtual reality set-ups, opening new windows on more complexly mediated interactions between patients and their to be controlled physiological responses. In the same vein, we developed a mediated oculomotor biofeedback prototype that allows the interacting subject to be immersed with virtual objects whose kinematical and textural properties change in real-time in function of gazing responses and pupillometric inputs[19].

We propose here a device to deliver specifically a combined penile/oculomotor biofeedback in order to help paraphiliacs be attuned to their physiological, behavioral and perceptual processes otherwise not directly perceptible to them and that engage their sexuality into reprehensible actions. This biofeedback device would mediate its feedbacks through virtual objects' behaviors. For instance, a patient showing signs of interest and/or sexual arousal when doing a virtual stroll nearby a simulated schoolyard could be continuously kept in resonance with his physiological reactions by the delivering of proportional changes in the ambiant sound and luminosity of the scene in which he would be immersed.

As for aversive conditioning, the coupling of aversive or sensitizing contingencies with sex-

ual responses could be done automatically, in a discrete fashion, when a preset criterion would be reached. For instance, a patient exceeding a preset criterion equivalent to 10% of his maximum erectile response and displaying at the same time a critical visual sampling pattern with regard to potential simulated victims would see himself provided with an aversive or sensitizing stimulus that could take the form of a virtual policeman entering the precinct; alternatively, the stimulus could be purely and simply a drastic removal from the scene to an other environment designed to be aversive, eg: a virtual cell or a virtual arrest situation or any event that would be particularly aversive to that individual.

CONCLUSION

Concrete applications of virtual reality in mental health are becoming more and more common. However, virtual reality applications for forensic science and correctional rehabilitation are still not very numerous. With the method put forward in this paper we tried to bring solutions to real and important psychological and social problems by using the immersive properties of virtual reality together with the analytical potential of eye-tracking technologies.

REFERENCES

1. Abel, G.G., Huffman, J., Warberg, B.W., & Holland, C.L. (1998). Visual reaction time and plethysmography as measures of sexual interest in child molesters. *Sexual Abuse: A Journal of Research and Treatment, 10,* 81-95.
2. Abel, G.G., Lawry, S.S., Karlstrom, E.M., Osborn, C.A. and Gillespie, C.F. (1994). Screening tests for pedophilia. *Criminal Justice and Behavior, 21 (1),* 115-131.
3. Basmajian, J. V. (1989). Biofeedback: Principles and Practice for Clinicians (3rd ed.), William & Wilkins, Baltimore.
4. Cho, B. H., Jang, D. P., Lee, J. M., Kim, J. S., Kim, S. I., Ku, J. H., Kim, I. Y., & Lee J. H. (2002). Attention Enhancement System using Virtual Reality and EEG Biofeedback. *IEEE Virtual Reality Conference 2002*, March 24-28, 2002, Orlando, Florida.
5. Harris, G.T., Rice, M.E., Quinsey, V.L. & Chaplin, T.C. (1996). Viewing time as a measure of sexual interest among child molesters and normal heterosexual men. *Behaviour Research and Therapy, 34,* 389-394.
6. Harris, G. T., Rice, M. E., Quinsey, V. L., & Chaplin, T. C. (1999). Dissimulation in phallometric testing of rapists' sexual preferences. *Archives of sexual behavior, 34*, 223-232.
7. Kalmus, E., & Beech, A.R. (2005). Forensic assessment of sexual interest: A review. *Aggression and Violent Behavior, 10*, 193-217.
8. Laws, D.R. (2001). Olfactory aversion: Notes on procedure, with speculations on its mechanism of effect. *Sexual Abuse: A Journal of Research and Treatment, 13,* 275-287.
9. Marshall, W. L., & Fernandez, Y. M. (2000). Phallometric testing with sexual offenders: Limits to its value. *Clinical Psychology Review, 20*, 807–822.
10. Palsson, O.S., & Pope, A.T. (1999). Stress counter-response training of pilots via instrument functionality feedback. Abstract, *Proceedings of the 1999 Association for Applied Psychophysiology and Biofeedback Meeting,* Vancouver, Canada.
11. Palsson, O.S., Pope, A.T., Ball, J.D., Turner, M.J., Nevin, S., & DeBeus, R. (2001). Neurofeedback videogame ADHD technology: Results of the first concept study. *Proceedings of the 2001 Association for Applied Psychophysiology and Biofeedback Meeting,* Raleigh-Durham, NC.
12. Palsson, O.S., & Pope, A.T. (2002). Morphing Beyond Recognition: The Future of Biofeedback Technologies. *Biofeedback, 30 (1),* 14-18.
13. Proulx, J., Cote, G., & Achille, F.J. (1993). Prevention of Voluntary Control of Penile Response in Homosexual Pedophiles During Phallometric Testing. *The Journal of Sex Research, 30,*140-147.
14. Quinsey, V.L., & Chaplin, T.C. (1988b). Preventing faking in phallometric assessments of sexual preference. In R. Prentky and V.L. Quinsey (Eds.), *Human sexual aggression: Current perspectives* (pp. 49-58). Annals of the New York Academy of Sciences, Vol. 528.
15. Quinsey, V.L., Chaplin, T.C., & Carrigan, W.F. (1980). Biofeedback and signaled punishment in the modification of inappropriate sexual age preferences. *Behavior therapy, 11*, 567-576.
16. Quinsey, V.L., & Lalumière, M. (1992). *The assessment of sexual offenders against children. The APSAC study guide.* California: Sage.
17. Renaud, P. (2004). Moving assessment of sexual interest into the 21st century : the potential of new information technology. Invited

speaker at *The 23rd Annual Research and Treatment Conference (Association for the Treatment of Sexual Abusers)*, Albuquerque, 27-30 October 2004.
18. Renaud, P., Albert, G., Sauvé, L., Renaud, L., Décarie, J., & Bouchard, S. (2004). Assessing perceptual learning dynamics during visual search in virtual immersion using eye-tracking technologies. *Proceedings of the IADIS International Conference on Cognition and Exploratory Learning in Digital Age*, Lisbon, Portugal: IADIS Press, pp. 413-418.
19. Renaud, P., Bernier, S., Décarie, J., Gourd, S.-P., & Bouchard, S., (2003a). Oculomotor biofeedback mediated in virtual immersion. *Proceedings of the Ninth International Conference on Virtual Systems and Multimedia : Hybrid Reality : Art, Technology and the Human Factor 2003 (VSMM)*, Montréal, pp. 732-740.
20. Renaud, P., Bouchard, S., & Proulx, R. (2002a). Behavioral avoidance dynamics in the presence of a virtual spider. *IEEE (Institute of Electrical and Electronics Engineers). Transactions in Information Technology and Biomedecine, 6 (3)*, 235-243.
21. Renaud, P., Cusson, J.-F., Bernier, S., Décarie, J., Gourd, S.-P., & Bouchard, S. (2002b). Extracting perceptual and motor invariants using eye-tracking technologies in virtual immersions. Proceedings of *HAVE'2002-IEEE (Institute of Electrical and Electronics Engineers) International Workshop on Haptic Virtual Environments and their Applications,* Ottawa, pp. 73-78.
22. Renaud, P., Décarie, J., Gourd, S.-P., Paquin, L.-C., & Bouchard, S. (2003b). Eye-tracking in immersive environments : a general methodology to analyze affordance-based interactions from oculomotor dynamics. *Cyberpsychology and Behavior, 6 (5),* 519-526.
23. Renaud, P., Rouleau, J.-L., Granger, L., Barsetti, I., & Bouchard, S. (2002c). Measuring sexual preferences in virtual reality: A pilot sudy. *Cyberpsychology and Behavior, 5 (1)*, 1-10.
24. Renaud, P., Singer, G., & Proulx, R. (2001). Head-tracking fractal dynamics in visually pursuing virtual objects. In Sulis W., Trofimova I. (Eds.), *Nonlinear Dynamics in Life and Social Sciences* (NATO Science series, Vol. 320), Institute of Science Press (IOS Press), Amsterdam, pp 333-346.
25. Rouleau, J.-L., Renaud, P., & Barsetti, I. (2001). Le traitement des agresseurs sexuels. In Séguin, M., Leblanc, L. (Eds.), *La relation d'aide* (pp 251-282). Montréal : Éditions Logiques.
26. Singer, B. (1984). Conceptualizing sexual arousal and attraction. *The Journal of Sex Research, 20 (3)*, 230-240.
27. Schwartz G.E., & Beatty J. (1977). *Biofeedback: Theory And Research*, Academic press, New York.
28. Stern, J.A, Walrath, L.C., & Goldstein R. (1984). The endogenous eyeblink. *Psychophysiology, 21*, 22-33.
29. Stern, J.A. & Dunham, D.N. (1990). The ocular system. In Caccioppo, J.T. & Tassinary, L.G. (eds.), *Principles of psychophysiology:physical, social and inferential elements* (pp. 513-553). Cambridge, U.K.: Cambridge University Press.

Contact

Patrice Renaud, Ph.D.
Laboratoire de cyberpsychologie
Département de psychoéducation et de psychologie
Université du Québec en Outaouais
Institut Philippe-Pinel de Montréal
C.P. 1250, Succ. B
Gatineau (Québec) Canada, J8X 3X7
patrice.renaud@uqo.ca
T. : 819 595 3900

Treating Acrophobia in a Virtual Environment

A. H. Bullinger[1], I. Angehrn[1], B. K. Wiederhold[2,3], F. Mueller-Spahn[1], R. Mager[1]

[1] COAT-Basel / UPK (Center of Applied Technologies in Neuroscience), University of Basel, Switzerland
[2] Interactive Media Institute, San Diego, USA
[3] Virtual Reality Medical Center, San Diego, USA

Abstract: *Specific phobias are one of the most frequent mental health problems and can lead to years of personal suffering. The most effective treatment is exposure therapy. Our aim was to proof the feasibility and efficacy of virtual environments in treating acrophobia patients using a manually guided exposure therapy. Our pilot study was designed as a crossover intervention with a waiting list condition as a control group. After treatment, our results show that exposure in virtual environments is a feasible technique can provoke anxiety, and leads to a therapeutic effect.*

INTRODUCTION

Anxiety disorders appear with a lifetime prevalence of about 25% (12). Chronic processes have been observed up to a percentage of 50% in agoraphobic, specifically phobic and sociophobic cases (24). Among these, specific phobias are the most widespread disorders (11, 16). Currently, the internationally accepted treatment strategy is behavior therapy with exposure (20, 21). Many trials have been conducted to substitute situations of exposure using computer-based simulations. Today one can say that the attempts to develop computer-based psychotherapy programs have not been very successful.

But, the early 1990s saw a change, brought about by the introduction of virtual reality (VR) systems in research at universities. Three-dimensional virtual environments are computer-generated interactive visualizations, in which the user is able to experience spatial and temporal correlations. Data helmets or specially designed presentation media, based on function units composed of screens and appropriate projectors, are used to produce the three-dimensional effects. In the last years, virtual environments have often been used by several research teams in Europe and the USA, to research, for example, acrophobia (3, 8), claustrophobia (4), arachnophobia (5) and fear of flying (9,26,27,28). This technique is also used to study addictions (cue exposure) (15). Furthermore, expectations are raised that by applying virtual environments as an exposure platform there will also be a great success in the investigation of the biological basis of specific phobias: Because the environments generated by the computer are always represented completely unmodified and exactly corresponding to the preceding and succeeding sequences, they are very suitable for studying the psycho-physiological stimulus-reaction conditions and for examining the therapeutic effects on these psycho-physiological reactions (23).

PILOT STUDY

METHODS

Study Design

At first, three test persons were exposed to altitude in VR while the other three test persons were supervised in a waiting list condition (WLC). WLC means that the test persons could perform self-selected computer games concurrently to the exposure therapy. After a break of three months the test persons in the WLC did the VR exposure, and the group that had already been exposed to altitude played on the computer.

In a preliminary talk the therapeutic rationale was discussed with the test persons. All of the six treatments (each with three exposures) were carried out by a therapist with many years

of clinical experience in psychiatry and training in cognitive behavior therapy. On the basis of empirical and theoretical models the origin, triggering factors and the perpetuating factors of the specific phobia were explained. Also the correlation of cognitive, affective and vegetative symptoms of anxiety with situational characteristics was described. The model of a dysfunctional interaction (also known as "vicious circle") of intrapersonal and external stimuli was well understood by the concerned people because of their own experience. Besides, the negative impact of anxiety-avoidance on the process of the disorder was emphasized. The program sequence and the expectations of the test person were clarified. The expectations were, at first, very skeptical and affected by frustration of many years, but after the medical education the attitude changed regularly into a rather hopeful one. The test persons were encouraged to frequent autonomously, in the period between the sessions, situations which they had avoided so far. All test persons were physically examined by a medical doctor. Therefore, somatic diseases sometimes related to anxiety syndromes could be excluded. In doing so, a psychiatric and medical anamnesis was made.

The diagnosis of a specific phobia (acrophobia) was made by the Composite International Diagnostic Interview (CIDI (25)). Other phobias or comorbid disorders according to ICD-10 and DSM IV (1) were excluded. Especially any psychotic disorder, suicide attempts in the anamnesis, disorders caused by using psychotropic substances like addiction, delirium and apparent physical disorders (especially considerably impaired vision or defective hearing) were criteria for exclusion.

The therapeutic effect was measured by means of self-evaluation on a 4-point-scale at 5 points in time: 4 of them were before and after exposure/waiting list (respectively waiting list/ exposure) and one interview was conducted 6 months later (figure 1a). We asked the test persons about the subjective evaluation of their discomfort (scale "comfort/discomfort") and their contentment (scale "contentment") and also about the dimension of phobic avoidance (scale "avoidance"). These 3 scales measured from "I feel very good" (point 1) to "I feel very bad" (point 4).
Furthermore, the concept of the Subjective Units of Discomfort (SUD (7)) was explained to the test persons. It refers to an individually "calibrated" rating of the actual anxiety and stress on a scale of 0-100. During the later exposure, the test person was asked, in intervals of 5 min, about the level of his anxiety/stress on a scale of 0 (conveniently balanced feeling) to 100 (maximal anxiety). The purpose of that was, on the one hand, to identify potential cognitive avoidance-strategies and on the other

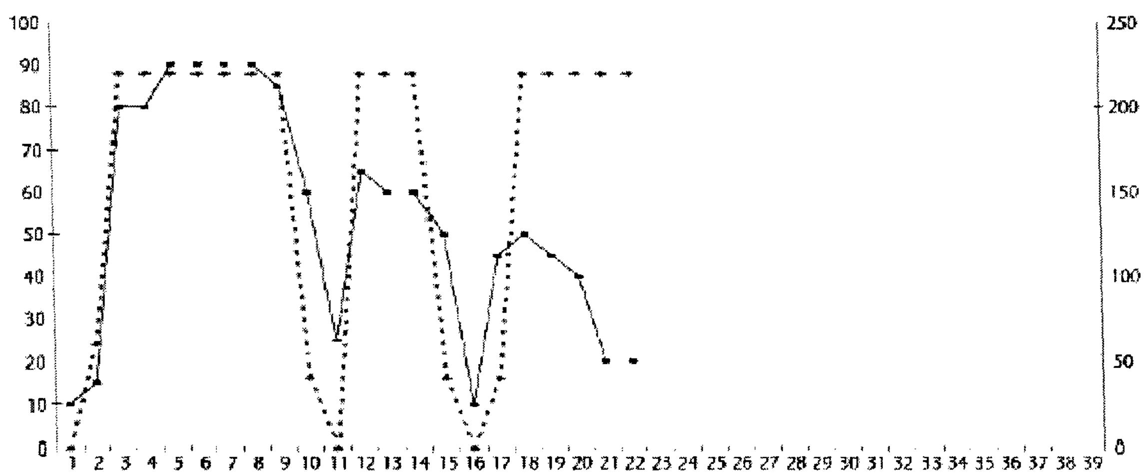


Figure 1. First exposure treatment of test person No. 5. The horizontal axis shows 39 intervals of 5 minutes. The left vertical axis indicates the dimension of anxiety (black line with squares) between 0 and 100, the right vertical axis indicates the altitude of the elevator in meters (maximal 220m, dashed line with lozenges)

hand to survey the impact of the virtual environment on the stress of the test persons. Furthermore, the test persons were asked to give their subjective evaluation regarding the dimension of the "worst" anxiety situation. The scale "maximal anxiety" was divided in 10 stages to simplify an adaptation to the 100 scale points of the SUDs.

The Virtual Environment

The computer-based program is generated by True Space, TCL (the software can be bought) and by Lightning (virtual interaction- and animation software especially created for our application, ICIDO Ltd., Stuttgart, Deutschland). The virtual environment is visualized by a Silicon Graphics (SGI) Onyx^2 Deskside System. For data transfer a Head Mounted Display (V8, Virtual Research), a Tracking System (Flock of Birds, Ascension) and an interaction medium (Space Mike, ICIDO Ltd.), also especially created for our application, were used.

The Exposure

The gradual exposure in VR was made by means of the aforementioned technique, altitude "situations" generated by the computer served to elicit anxiety. A manual was used and (13) served to assure standardization of the therapy process; the virtual environment was always generated homogenously by the computer.

The manual consisted of an introduction to the technique and information about specific phobias as well as a therapy schedule.

- In session 1, in addition to the diagnosis via the CIDI and the medical examination, a behavioral analyses (problem definition, analyses of condition and function, developing an individual phobia hierarchy) was made. The identification of further problem areas completed the data acquisition.
- In the second session the therapy rationale, the schedule and the expectations were discussed. The test person received instructions for practicing in-between the sessions.
- In session 3 to 5, the test person was confronted with the virtual environment.

In a final session the experience of the test person made during the therapy was discussed. The person was again encouraged to continue confronting himself with situations he had avoided so far.

The first of three confrontations was dominated by the cognition of anxiety. The test person should, if possible, experience maximal occurrence of anxiety cognitions, anxiety feelings and anxiety physiology. Every session lasted 2-4 hours. During the exposure the test person was asked every 5 min about the level of his anxiety/stress measured on a scale ranging from 0-100 (SUDs). After having surpassed the point of culmination of the emotional-vegetative reaction, the exposure continued until the test person showed a significant subjective ease (scale: <30).

The test person was instructed to verbalize clearly his perception. The therapist was empathic-supporting and motivated the test person to endure the situation. In principle, the decision to drop out or to continue the exposure was not made by the therapist. If the test person wanted to drop out, the therapist was supposed to encourage him to continue. An "emergency-stop procedure" has been arranged individually (i.e. verbal signs as "Stop, it is enough").

Test Persons

The test persons were people from the German-speaking area around Basel. There was an advertisement in the newspaper and in the period from February 2000 to January 2001, 38 persons answered the advertisement. Twenty of them could be excluded already on the phone, because either they did not have acrophobia or they had some other symptoms as i.e. eating disorders, alcohol addiction, and agoraphobia. Eighteen people were invited to a preliminary talk, but 4 of them cancelled it beforehand. After the 14 preliminary talks, 2 persons withdrew their consent for the treatment. 6 of the remained 12 persons were selected via a random generator and were accepted for the pilot study.

All 6 test persons were male and did not suffer from a further somatic mental disorder. They were socially well-integrated and employed. The mean age was 37.8 years.

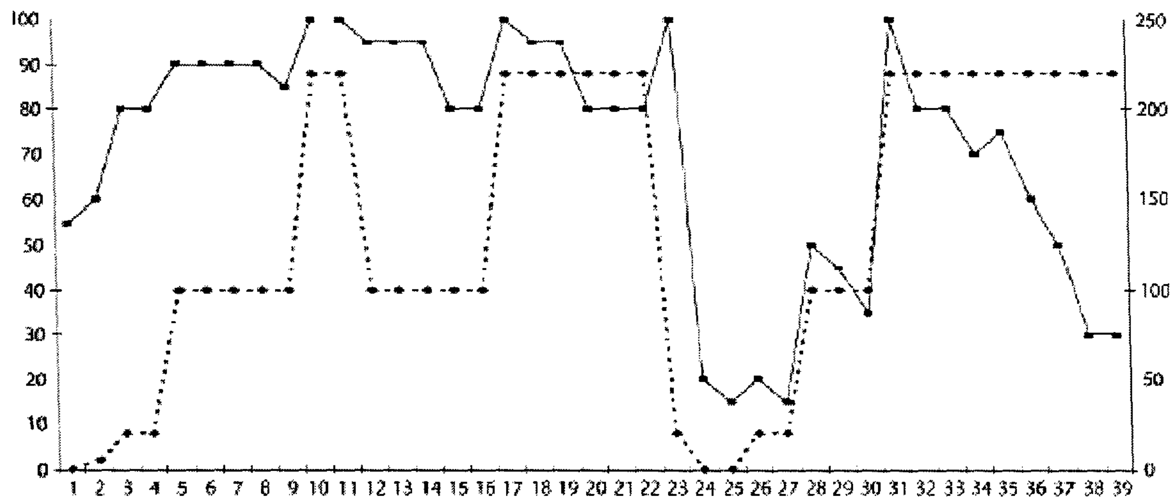


Figure 2. First exposure treatment of test person No. 6. The horizontal axis shows 39 intervals of 5 minutes. The left vertical axis indicates the dimension of anxiety (black line with squares) between 0 and 100, the right vertical axis indicates the altitude of the elevator in meters (maximal 220m, dashed line with lozenges)

RESULTS

The object of this pilot study was to examine the feasibility and the efficacy of virtual environments in treating acrophobia patients. The exposure was without any relevant incidents and the individually arranged "emergency-stop" was never used.

Positive effects of the exposure in the virtual environment could be observed for all test persons. Exemplary results of the 18 exposures are graphically illustrated in figure 1, 2 and 3. Figure 1 represents a "classical" exposure process within 105 min: At the beginning the anxiety increased synchronously with the altitude. In the subsequent 2 confrontations, the amplitude of the subjectively experienced anxiety decreased significantly and ends after 105 min with less than 30 SUDs. In the second case (figure 2), the anxiety was already at the beginning very distinct. The exposure was slow and

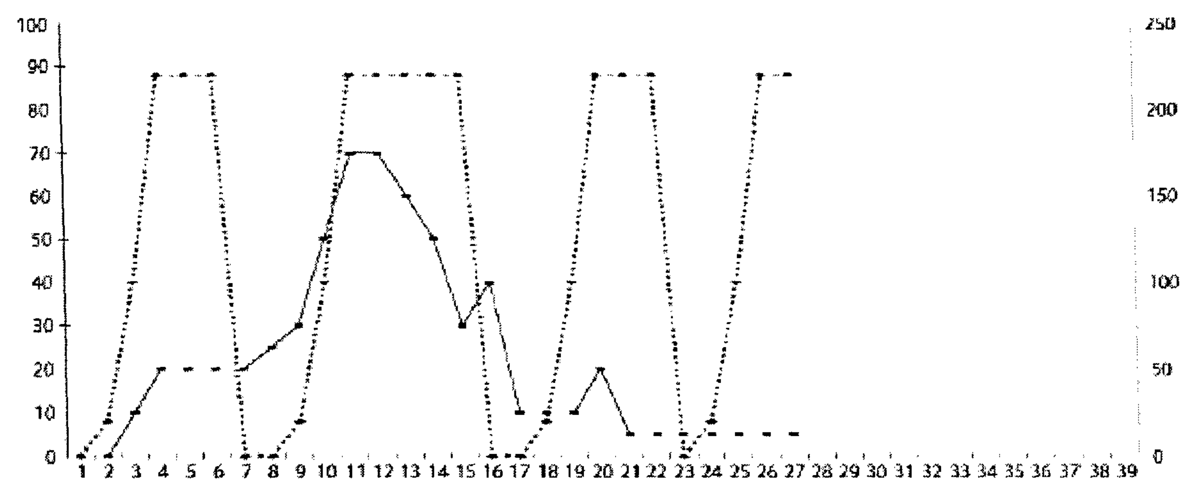


Figure 3. First exposure treatment of test person No. 4. The horizontal axis shows 39 intervals of 5 minutes. The left vertical axis indicates the dimension of anxiety (black line with squares) between 0 and 100, the right vertical axis indicates the altitude of the elevator in meters (maximal 220m,

gradual and reached only after approximately 50 min the maximal altitude. The anxiety became almost insupportable for the test person and a reduction of altitude implicated almost no release. After about 100 min the anxiety diminished in spite of subsequent maximal altitude-exposure. The fast virtual downward trip by the elevator resulted firstly in an increase of anxiety but finally in a great release. After 160 min a reduction of anxiety can be observed ending after almost 200 min with a SUD of approximately 30. Figure 3 shows a prolonged rise of anxiety. Only at the second time of maximal altitude the stress level had a relevant value of about 70 SUDs. The release occurred soon and was maintained also after new confrontation. After 145 min the exposure was stopped having a stable SUDs of less than 10.

Figure 4 shows, resuming all 5 measurements, the test persons' self-evaluation concerning "contentment", "discomfort", "avoidance" and

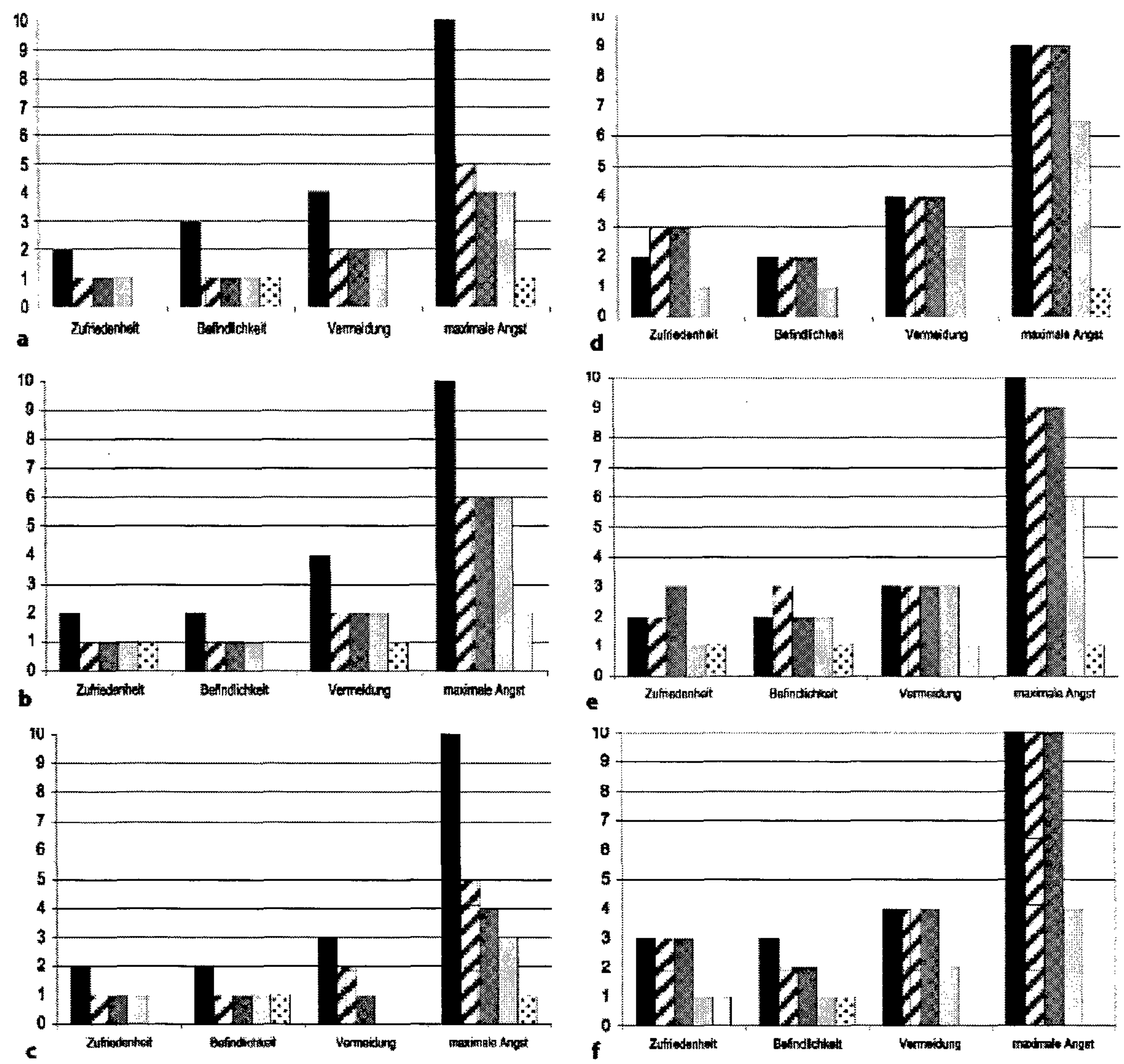


Figure 4a-f. Illustration of therapy effects concerning "contentment" [Zufriedenheit], "comfort/ discomfort" [Befindlichkeit], "avoidance" [Vermeidung] and "maximal anxiety" [maximale Angst]: **a-c** represents test person no. 1-3; **d-f** represents test person no. 4-6. Time of enquiry: measuring 1 (black), measuring 2 (diagonally striped), measuring 3 (dark grey), measuring 4 (medium grey), in-

maximal anxiety in single situations. One can see that all test persons experienced the therapy as successful. This estimation was stable for 6 months: The subjectively felt comfort increased and previously avoided situations were frequented more and more and were experienced with decreasing anxiety. Discontent, discomfort and the degree of avoidance were evaluated by the test persons on a scale ranging from 0 (no problem) to 4 (every altitude with more than 5 m was avoided). The evaluations were to be explicitly subjective and general. In terms of "discontent" the test person was asked to what extent he was discontent because of his phobia. With regard to "comfort/discomfort" he was asked how much the phobia affects his physical and mental orientation. An occurrence of 2 and 3 improved to 0-1. "Avoidance" meant the avoidance of being in altitude. This avoidance was at the beginning 3-4 and after 6 months only 0-1. The occurrence of anxiety was also quantified by a 0-100-scale. All test persons experienced values of 90 or even more before they underwent the therapy. After 6 months the Subjective Units of Discomfort were only around 10.

DISCUSSION

The pilot study shows that an exposure in a virtual environment is possible and evokes anxiety among patients suffering from a specific phobia and has therapeutic effects. It has not been clarified so far to what extent habituation-processes and to what extent cognitive restructurings took place.

Possible side effects of virtual environments are sickness in the simulator (2) or impaired vision after the exposure (18). According to our inquiry none of the 6 test persons experienced such or other side effects. The experience was dominated by anxiety symptoms as i.e. sweating, gastrospasms, nervousness and sometimes even "panic" anxiety. The pressure of the data helmet on the head, vertigo, sickness or further disturbances were not said to be disagreeable. It can be supposed that because of the subjective threat of the virtual altitude such further disagreeable feeling have been suppressed. Compared to exposures in vivo, the test persons showed –in vitro- very similar reaction patterns. It is remarkable that nobody used the emergency-stop even if they often talked about doing it. In a real exposure such moments are very critical because the avoidance is easy to do. Drop-out is known as a common strategy and is almost automated. The very different way of the virtual environment could be a cesura in this automation. These experiences have to be interpreted with caution. The test persons were typical for specific phobic disorders insofar as the beginning of the disorder was in early adulthood and was chronically restricting. Among all the healing attempts there were psychotherapeutic treatments of "school psychology", so-called alternative intervention and even esoteric practices. Some of our test persons also tried sporadically to reduce their anxiety in taking "benzodiazepines" or alcohol.

Because of using self-evaluation-scales there is another limitation of the data. This process is common in therapeutic terms, but leads to difficulties in the evaluation of the data and in its comparability. The technique of the VR could be a great advantage because of its standardization. During exposure, additional physiological parameters (23) could be measured forming the objective of the so far only subjective aspect of anxiety. In this case, the investigation of the biological basis of the specific phobias is auspicious by means of using virtual environments as an exposure platform. Because the computer-generated environments are always represented completely unmodified compared to the preceding and succeeding processes, they are suitable for the study of the psycho-physiological stimulus-reaction conditions and for the examination of the therapeutic effects resulting from these psycho-physiological reactions.

CONCLUSION

Our pilot study showed an improvement in all the measured domains (contentment, comfort/discomfort, anxiety occurrence, avoidance). The occurrence of the test person's anxiety diminished significantly during exposure. Situations previously avoided were frequented. General life-contentment and comfort rose. The improvement after the therapy is very evident among the test persons. The waiting condition "computer games" changed nothing. After 6 months the positive results could still be ob-

served and they even continued to improve. These results correspond to our own therapeutic experience as well as to other published studies (8, 9, 10, 17, 19, 20, 22, 26, 27, 28).

REFERENCES

1. American Psychiatric Association (1994), Diagnostic and Statistical Manual of Mental Disorders (DSM 4th edn).Washington, DC
2. Baltzley DR, Kennedy RS, Berbaum KS, Lilienthal MG (1989), The time course of postflight simulator sickness symptoms. Aviation Space Environm Med 60(11):043–1048
3. Bullinger A, Roessler A, Mueller-Spahn F (1998), 3D-Virtual Reality as a Tool in Behavioral Therapy of Claustrophobia. CyberPsychol Behav 1(2):139–145
4. Bullinger A, Roessler A, Mueller-Spahn F (1998), From Toy to Tool: the Development of Immersive Virtual Reality Environments for Psychotherapy of Specific Phobias.Stud Health Technol Inform 58:103–111
5. Carlin AS, Hoffman HG, Weghorst S (1997), Virtual reality and tactile augmentation in the treatment of spider phobia: A case report. Behav Res Ther 35(2):153–158
6. Cartwright GF (1994), Virtual or real? The mind in cyberspace.Futurist 22–26
7. Foa EB,Rothbaum BO (1998), Treating the trauma of rape. Cognitive-behavioral therapy for PTSD. Guilford Press,New York
8. Hodges LF,Kooper R,Rothbaum BO,Opdyke D, de Graaff JJ,Williford JS,North MM (1995), Virtual environments for treating the fear of heights. Comput Innov Technol Comput Profess 28(7):27–34
9. Hodges LF,Rothbaum BO,Watson BA,Kessler GD,Opdyke D (1996), Virtually conquering fear of flying. IEEE Comput Graph Applic 16(6):42–49
10. Jacobs M, Christensen A, Huber A,Polterock A (1995), Computer-assisted individual therapy vs. standard brief individual therapy. In: Jacobs M (chair) Computer-psychotherapy: Wave of the future? Symposium conducted at the meeting of the Western Psychological Association, Los Angeles
11. Kaplan HI, Sadock BJ,Grebb JA (1994), Synopsis of Psychiatry – Behavioral Sciences – Clinical Psychiatry (7th edn).Williams & Wilkins, Baltimore
12. Katschnig H, Stolk JM, Klerman GL, Ballenger, JC (1992), Discontinuation and long-term followup of participants in a clinical drug trial for panic disorder. Biol Psychiatry 1:657–660
13. Kuntze M (2000), Therapiemanual zur graduierten Expositionstherapie in „Virtueller Realität“ zur Behandlung der spezifischen Phobie.COAT, Basel
14. Kuntze M, Mueller-Spahn F, Mager R, Stoermer R, Bullinger AH (2002), Ethics and Values in a Virtual Environment.10th Medicine Meets Virtual Reality Conference, Newport Beach CA, USA
15. Kuntze MF, Stoermer R, Mager R, Roessler A, Mueller-Spahn F, Bullinger AH (2001), Immersive Virtual Environments in Cue Exposure. CyberPsychol Behav 4(4) 497–501
16. Margraf J (1996), Lehrbuch der Verhaltenstherapie, Bd 1, 2. Springer,Berlin Heidelberg New York
17. Margraf J, Schneider S (1990), Panik – Angstanfälle und ihre Behandlung.Springer, Berlin Heidelberg New York
18. Mon-Williams M,Wann JP, Rushton S (1993), Binocular vision in a virtual world: Visual deficits following the wearing of a head-mounted display. Ophthal Physiol Optics 13 (4):387–391
19. North MM,North SM,Coble JR (1996), Virtual reality therapy. IPI Press, Colorado Springs
20. Oest LG (1996), Spezifische Phobien. In: Margraf J (Hrsg) Lehrbuch der Verhaltenstherapie,Band 2. Springer, Berlin Heidelberg New York
21. Rachman S,Taylor S (1993), Analyses of claustrophobia.J Anx Disord 7(4):281–291
22. Rothbaum BO, Hodges LF, Kooper R, Opdyke D, Williford JS, North M (1995), Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia. Am J Psychiatry 152:626–628
23. Stoermer R, Mager R, Roessler A, Mueller-Spahn F, Bullinger A (2000), Monitoring Human-Virtual Reality-Interaction: a Time Series Analysis Approach. CyberPsychol Behav 3 (3):401–406
24. Wittchen HU (1991), Der Langzeitverlauf unbehandelter Angststörungen: Wie häufig sind Spontanremissionen.Verhaltenstherapie 1:273–283
25. Wittchen HU, Semler G (1991), Composite International Diagnostic Interview (CIDI). Beltz Test,Weinheim

26. Wiederhold, B.K. (1999). "A comparison of imaginal exposure and virtual reality exposure for the treatment of fear of flying" [doctoral dissertation]. California School of Professional Psychology.
27. Wiederhold, B.K. & Wiederhold, M.D. (2000). "Lessons Learned From 600 Virtual Reality Sessions." CyberPsychology & Behavior. 3 (3): 393-400.
28. Wiederhold, B.K., Wiederhold, M.D., (2005). Virtual Reality Therapy for Anxiety Disorders- Advances in Evaluation and Treatment. Washington, DC: American Psychological Association.

Contact:

Alex H. Bullinger
COAT-Basel / UPK
Wilhelm Klein – Str- 27
4025 Basel, Switzerland
bua@coat-basel.com

Virtual Environments to Address Autistic Social Deficits

C. Y. Trepagnier, Ph.D., M. M. Sebrechts, A. Finkelmeyer, M. Coleman, W. Stewart, Jr., M. Werner-Adler,

The Catholic University of America, Washington, DC

Abstract: Background: *Autistic Disorder is defined by social and communicative impairments and restricted, narrow interests. Impaired motivation is also common. Several investigators have developed computer-based and virtual environment tools to address various issues in autism(1-5). Four projects at CUA address the social impairment.*

Method/Tools: *Face Processing. The prediction that autistic face processing impairment involves gaze differences was tested in an eye tracking study using a VR display. A replication in progress uses a monitor. Early Intervention. A virtual environment, with kiddie-ride, monitor display and eye tracker, is being tested. The goal is to induce young children with autism to attend to faces. Social Navigation. A joystick-navigable, first-person-perspective shopping mall is presented on a monitor. To locate objects, the user must move either between or around social and non-social obstacles. Data include user comments and path records. Training in Social Conversation. SIMmersion LLC™ are collaborating with us to develop a social conversation module for adults with Asperger's Disorder. A virtual character remembers the conversation and responds as would an actual interlocutor to the user's speech.*

Results: *Face Processing. Preliminary results (with headset) confirmed gaze differences(6). The replication is in progress. Early intervention. Reliability-testing is being completed. Social Navigation. Controls describe their avatar's actions in the first person, and refrain from walking between conversing characters. Data collection with persons with autism has begun. Training in Social Conversation. Development is in progress.*

Discussion: *The projects described above derive from the hypothesis that failure to establish species-typical face attention and processing itself undermines cognitive development(7). Accordingly face processing is targeted in young children, and compensatory training is addressed with older individuals. The challenge is to make the technology not only effective, but adequately entertaining to overcome autistic motivational barriers.*

INTRODUCTION

Autism Spectrum Disorder (ASD) is characterized by impairment in verbal and nonverbal communication skills and social interaction, and the presence of repetitive behavior and narrow, obsessive interests, according to the standard diagnostic criteria used in research over the past decade.[1] While ASD can be diagnosed as early as 18 months, and most individuals are diagnosed by or near the start of their educational career, some are not identified until later childhood or even adulthood.

Facial expressions and gestures often hold little meaning for individuals with ASD. As a result it can be very difficult for them to make sense of people's behavior. During adolescence and young adulthood some individuals with ASD develop enough insight to become aware that they are different from their peers, and experience loneliness and sadness.

Once thought to be rare, ASD and related disorders are now being identified in large numbers. Prevalence estimates range from 15 to 60 per 10,000 individuals.[2,3] The symptoms of autism can be mitigated and quality of life improved thanks to evidence-based treatments such as intensive, autism-specific intervention in early childhood,[4,5] and psychopharmacological interventions.[7,8] Despite the popular percep-

tion of autism as a disorder of childhood, most individuals with ASD are adults.

In summary, there is a large population of children and older individuals who have severe deficits in their ability to interpret facial expressions and other nonverbal behavior; and equivalent lacks in their ability to transmit communication through these channels. The ASD syndrome results in a variety of social impairments that constitute major obstacles to the individual's possibilities of achieving independence and sustained employment, and having friends and intimate relationships.

Interventions to modify the young child's developmental course, or to teach older individuals skills that were not acquired naturally in childhood cannot approach in duration or intensity the on-going, unavoidable social instruction that is experienced by typically developing individuals. The most intensive autism intervention programs are offered primarily to young children (generally aged two to four), and these programs target a range of skills, among which social interaction is not an important focus. Intensive programs in social skill acquisition for older children are rare; for adolescents and adults with ASD they are largely unavailable, and the majority of such programs are not based on scientific evidence.

Virtual environments have been shown to be clinically useful for distraction from pain[8,9] and in the treatment of phobias[10-13] and are being investigated for their applicability to a number of other medical and psychiatric problems. Several investigators have developed computer-based and virtual environment tools to examine social behavior in autism[14-16] and to improve face processing, emotion recognition, and social problem solving.[17-19] The Autism Research Group at The Catholic University of America shares this focus on exploiting computer and virtual reality technology to develop techniques to improve the social competence of individuals with autism.

Our motivation for approaching autism mitigation through the social deficits grew out of the recognition of the centrality of the social deficit in autism,[20] and observation and review of face processing impairments and presence of symptoms of anxiety and depression in individuals with ASD,[21] findings that continue to be confirmed in more recent studies (e.g., face processing impairment[22,23]; psychiatric comorbidity[25-28]). It was hypothesized that infant onset of symptoms of anxiety and depressive disorder could disrupt face attention, with the consequence that the bases of face processing would not be established during the period when the infant is most apt, biologically, neurologically and behaviorally, for face processing to take root.[29] Following is a brief description of four projects at CUA that address autistic social impairments: Face Gace, Early Intervention, the Virtual Mall, and development of a Simulation to Train Conversational Interaction

FACE GAZE

These studies addressed the hypothesis that autistic differences in face processing would have correlates in gaze behavior, specifically that people with ASD would not look at the same locations on the face as controls. By means of a VR headset in which an eye tracking camera was installed significant differences were found between groups: while typically developing participants looked at the interior of the face, persons with ASD showed a greater tendency to look at the periphery.[29] Since use of the headset excluded many potential participants, a replication using a monitor and desktop eye tracker was next undertaken. Preliminary analysis of these data has found a significant correlation between gaze at the eye area and lesser impairment on the social component of the Autism Diagnostic Interview- Revised (ADI-R),[30] an instrument that focuses primarily on the individual's behavior at age four. This finding suggests that deficits in early social development may have a lasting effect on how these individuals look at faces. Since foveal and perifoveal vision are restricted to a narrow angle, gaze directed at the facial periphery[29] or at the mouth[32] fails to take in with adequate acuity the information necessary for interpreting facial expression.

EARLY INTERVENTION

An outgrowth of this project has been to propose an intervention to teach young children with autism to direct their gaze to the eye area

of the face, and to convey that attention to the eye area has inherent functional benefits. The goal of this project, therefore, is to develop and pilot a technique to induce children with ASD aged 24 to 54 months to attend to the meaningful areas of faces, and to make use of the information transmitted by them. In order to accomplish this it is critical to attract and sustain the child's participation, in addition to differentially rewarding the target gaze behaviors, as sensed by a desktop eye tracker. The rewards available for this purpose include a wide range of videos, and 'rides' in the 'kiddie' helicopter in which the monitor and tracker are installed. Current testing addresses the validity of our 'semi-automatic' calibration technique for children, and adjustments to the positioning of a child car-seat and head-rest for head stabilization adequate for reliable eye tracking. A pre-pilot study beginning in May will assess the feasibility of the training schedule for children and their families.

VIRTUAL MALL

Young children with autism may exhibit a variety of reactions to finding themselves in large, busy environments such as airports and shopping malls. Among the reactions particularly disconcerting for parents can be an apparent insensitivity to the presence of other people, treating them as mildly inconvenient obstacles that will give way on approach or even contact. As adolescents and adults, some people with ASD still seem unaware of social spatial conventions, walking between two people engaged in conversation with each other, or passing between a person and a display window at which she is looking. The Virtual Mall is being developed with the participation of non-disabled and ASD adults through an iterative design process, using standardized tasks to draw the user to explore the environment and encounter its social navigational challenges. The long-term goal is the development and evaluation of a clinically practical and ecologically valid assessment of social cognition, and a rehabilitation modality to improve the ability of individuals with ASD to function in everyday environments.

Data has been compiled from 8 participants' comments during and after performance of the tasks, as well as an automatically acquired record of their navigation paths. Participants to date have been 4 females and 4 males (one with an ASD diagnosis), 7 of whom were Caucasian and one African-American, ranging in age from 19-27 (Mean age 20.9).

Virtual activities were defined in detail for the human factors trials in order to assure that all participants experienced all of the challenges of the mall, including virtual humans and inanimate objects, situated at locations that require participants to navigate through or around them in order to reach their target. Placement and orientation of the virtual humans creates situations that are identical in terms of spatial properties (e.g. space between humans and walls, or between obstacles and walls) but differ importantly in social implications (e.g., passing between a person and a store window to which her back is turned, versus passing between two characters facing each other at a conversational distance vs. passing between two advertising signs). Choice of path and distance between the operator's avatar and obstacles (other humans, inanimate objects and walls) are interpreted as relating to participants' experience of the ecological validity of this environment. To the extent users' verbal descriptions, comments and navigational decisions suggest adequate ecological validity, the environment is considered to have potential as a tool for use in assessing and intervening with individuals with social impairments, including autism.

The controller used was a joystick with minimal displacement, that moved the avatar in the direction that force was applied. Participants were trained in the operation of the controls by following_a path through large virtual mall corridors, during which they were instructed to avoid collision with walls and obstacles. Next they were familiarized with the layout of the mall by following experimenter instructions to navigate to each of the individual stores. The target location task entailed navigating to four different stores to locate in each a box containing a colored, numbered sphere. The experimenter named the store in which the next target could be found, and the participant's task was to locate the box, which opened once s/he was within range, and to read out the number and name the color. Participants performed two

runs of the target location task, each with a different order of shops, and runs were counterbalanced across participants.

Participants were asked to 'think out-loud' as they performed the tasks. This instruction was later modified to " Describe what you are doing." At the end of the session, participants were invited to comment on the experience and identify anything they liked or disliked.

Individual participant comments were recorded and were coded for indication of perceived realism in the environment. For example, use of the first person to refer to one's own avatar, and imputation of agency and/or mental state to other artificial humans were treated as indications of perceived ecological validity.

Participants' paths through the environment were recorded. After the first four participants' experience, speech output was added, and the distance of two sets of obstacles from the store entrances they blocked was increased. Visualizations of the paths taken by participants before and after these changes were implemented are

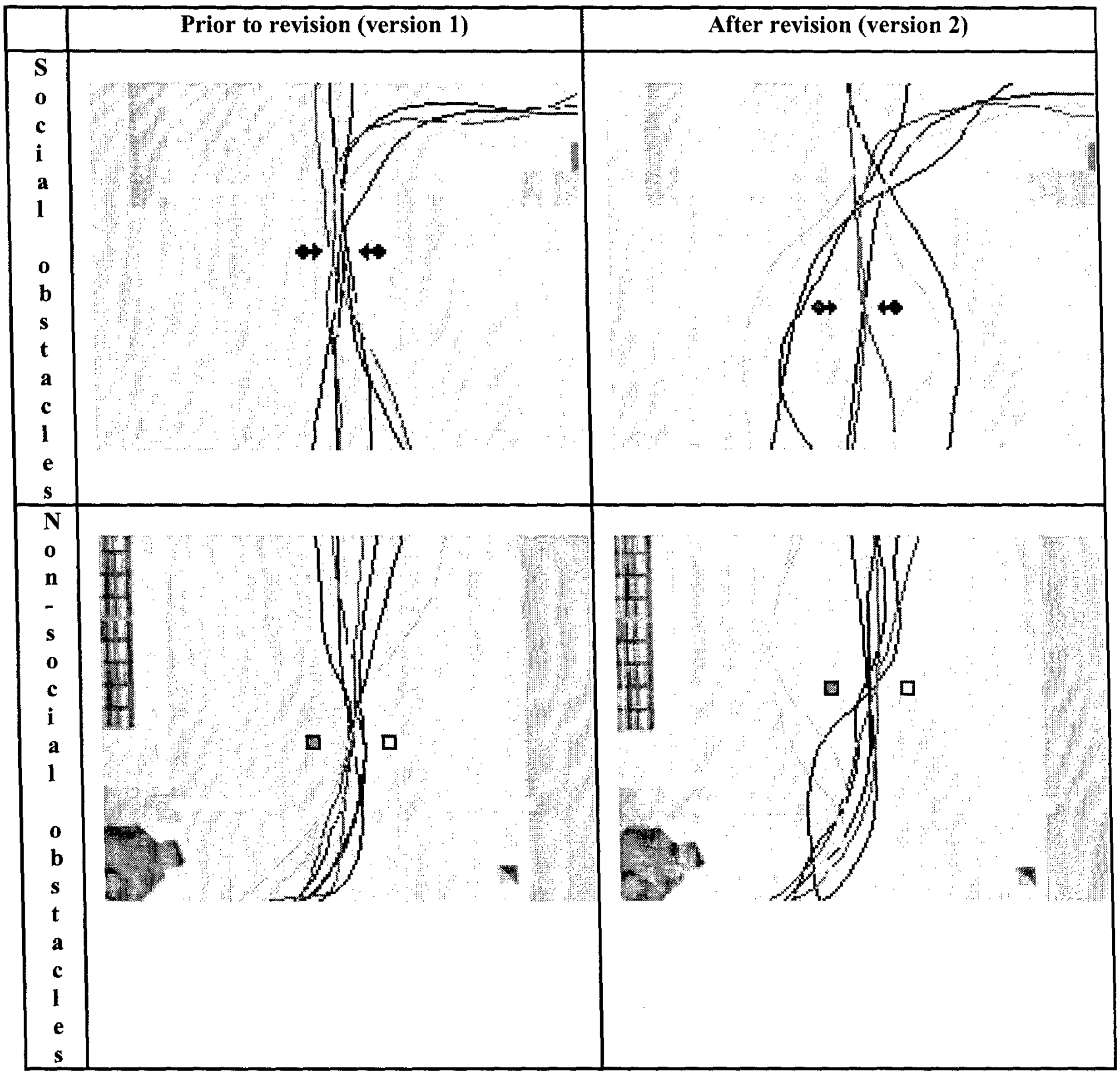


Figure 1.

shown in Figure 1. All four participants using Version 1 (no speech) walked between the two characters who were facing each other, both on entering and exiting the store, and., similarly, walked between the two inanimate objects. In contrast, participants who used the Version 2 of the mall, to which speech had been added, were more likely to walk around the now audibly conversing characters, rather than between them, while all navigated between the inanimate objects, despite the increased ease of circumnavigating both pairs of obstacles.

Figure 1: Paths taken in the vicinity of social (virtual humans) vs. non-social (objects) obstacles, by participants experiencing Versions 1 and 2 of the Virtual Mall. Arrows indicate the direction the virtual humans are facing. In Version 2 the two people facing each other can be heard to converse. In addition, in Version 2, both the pair of people and the pair of objects have been moved farther from the door, so that it is easier to go around both rather than passing between the two members of the pair.

Participants were able to learn rapidly to navigate the mall, and locate the targets. Review of participants' paths and their verbal comments during and after participation suggest that their navigational decisions reflect their awareness of social constraints. They used the first person in describing their avatar's movement and intentions, irrespective of whether they experienced a first-person or a third-person perspective. They tended to ascribe agency and even mental states to the virtual humans. One participant, passing near a virtual human, said "Excuse me!"

In addition, they tended to refrain from walking between characters who were facing each other, when the characters were audibly conversing. The gain in eliciting socially appropriate responses from addition of speech is a promising indication for further development of the mall as an evaluative and training tool. Additional design trials are planned with younger individuals with ASD and controls matched for nonverbal mental age.

SIMULATION TO TRAIN CONVERSATIONAL INTERACTION

Lack of success in initiating and, especially, in maintaining a conversation is a hallmark of ASD. The impoverished opportunities and poor success rate of peer interaction persists into older adolescence and adulthood,[32] presenting an obstacle to the casual social interaction that is a part of much of human activity. Participating in a conversation involves, among other things, turn-taking, gaining awareness of the topic of the conversation, interpreting the partner's nonverbal as well as verbal cues and knowing when and how it is appropriate to change the topic.

The Autism Research Group is collaborating with SIMmersion LLC™ to develop an interactive social conversation simulation for adults with high-functioning ASD.

In this system, the simulated character (represented by a data-base of video clips performed by an actor) remembers the conversation history and responds as would an actual interlocutor to the user's speech.

Structure is provided by the responses offered for the user's choice. The simulated character's verbal and nonverbal responses, and his willingness to continue the interaction provide intrinsic feedback.. At the same time, cues are available from a help agent in a separate window who enthusiastically applauds when the user chooses an appropriate question, and covers her face with both hands when the user's response choice is inappropriate. Each play of the simulation is different, the interaction is compelling, and there is the possibility of improving one's score each time. These game-like aspects of the simulation are expected to help motivate the user to play the simulation repeatedly and thus build his/her conversation skills.

The goal is to provide the individual with increasingly successful experience, supported, to the extent s/he chooses, with simplified instruction and reviewing of parts or all of the past conversation, that can be pursued in a nonthreatening environment, in order to develop a base of conversational skills.

DISCUSSION

Individuals with ASD have missed out on much of the experience required for social and cognitive development, possibly because of disruption to their development in infancy as a result of heavy genetic liability to anxiety/depressive disorders leading to very early onset of symptoms of these genetically related disorders (Trepagnier, 1996). These individuals require training appropriate to their developmental level to improve the success of their social interactions, thereby raising the likelihood that they will become more integrated into their community. Computerized and virtual reality technologies enormously broaden the scope of possible interventions. The dual challenge is to make technology-based interventions both efficacious in inculcating gains in social skills and entertaining enough to overcome autistic motivational barriers, so that consumers and their families, educators and clinicians will use and benefit from them.

REFERENCES

1.American Psychiatric Association (1994). Diagnostic and Statistical Manual - Revised. Washington, DC: author.
2. Fombonne E. (2003). Epidemiological surveys of autisma and other pervasive developmental disorders: an update. J Autism Dev Disord. 33(4): 365-82.
3. Lauritsen MB, Pedersen CB, Mortensen PB. (2004) The incidence and prevalence of pervasive developmental disorders: a Danish population-based study. Psychol Med. 34(7):1339-46.
4. Smith T, Groen AD, Wynn JW (2000). Randomized trial of intensive early intervention for children with pervasive developmental disorder. Am J Ment Retard. 105(4):269-85.
5. Eikseth S, Smith T, Jahr E, Eldevik S. (2002). Intensive behavioral treatment at school for 4- to 7-year-old children with autism. A 1-year comparison controlled study.Behav Modif. 2002 Jan;26(1):49-68.
6. Hollander E, Phillips AT, Yeh CC. (2003). Targeted treatments for symptom domains in child and adolescent autism. Lancet 30;362 (9385):732-4.
7. McCracken JT, McGough J, Shah B, Cronin P, Hong D, Aman MG, Arnold LE, Lindsay R, Nash P, Hollway J, McDougle CJ, Posey D, Swiezy N, Kohn A, Scahill L, Martin A, Koenig K, Volkmar F, Carroll D, Lancor A, Tierney E, Ghuman J, Gonzalez NM, Grados M, Vitiello B, Ritz L, Davies M, Robinson J, McMahon D. (2002). Risperidone in children with autism and serious behavioral problems. N Engl J Med. 347(5):314-21.
8. Steele E, Grimmer K, Thomas B, Mulley B, Fulton I, Hoffman H. (2003). Virtual reality as a pediatric pain modulation technique: a case study. Cyberpsychol Behav. 6(6):633-8.
9. Gershon J, Zimand E, Pickering M, Rothbaum BO, Hodges (2004). A pilot and feasibility study of virtual reality as a distraction for children with cancer. J Am Acad Child Adolesc Psychiatry. 43(10):1243-9.
10. Garcia-Palacios A, Hoffman H, Carlin A, Furness TA 3rd, Botella C. (2002). Virtual reality in the treatment of spider phobia: a controlled study. Behav Res Ther. 2002 Sep;40 (9):983-93.
11. Wiederhold BK, Jang DP, Gevirtz RG, Kim SI, Kim IY, Wiederhold MD (2002). The treatment of fear of flying: a controlled study of imaginal and virtual reality graded exposure therapy. IEEE Trans Inf Technol Biomed. 6 (3):218-23.
12. Wiederhold BK, Wiederhold MD. (2003). Three-year follow-up for virtual reality exposure for fear of flying. Cyberpsychol Behav. (4):441-5.
13. Vincelli F, Anolli L, Bouchard S, Wiederhold BK, Zurloni V, Riva G. (2003). Experiential cognitive therapy in the treatment of panic disorders with agoraphobia: a controlled study. Cyberpsychol Behav. 6(3):321-8.
14. Parsons S, Mitchell P. (2002). The potential of virtual reality in social skills training for people with autistic spectrum disorders. J Intellect Disabil Res. 46(Pt 5):430-43.
15. Parsons S, Mitchell P, Leonard A. (2004). The use and understanding of virtual environments by adolescents with autistic spectrum disorders. J Autism Dev Disord. 34(4):449-66.
16. Parsons S, Mitchell P, Leonard A. (2005). Do adolescents with autistic spectrum disorders adhere to social conventions in virtual environments? Autism. 9(1):95-117.
17. Silver M, Oakes P.(2001). Evaluation of a new computer intervention to teach people with autism or Asperger syndrome to recognize and predict emotions in others. Autism. 5(3):299-

316.
18. Bolte S, Feineis-Matthews S, Leber S, Dierks T, Hubl D, Poustka F. (2002). The development and evaluation of a computer-based program to test and to teach the recognition of facial affect. : Int J Circumpolar Health. 61 Suppl 2:61-8.
19. Bernard-Opitz V, Sriram N, Nakhoda-Sapuan S. (2001). Enhancing social problem solving in children with autism and normal children through computer-assisted instruction. J Autism Dev Disord. 31(4):377-84.
20. Fein D, Pennington B, Markowitz P, Braverman M, Waterhouse L.Toward a neuropsychological model of infantile autism: are the social deficits primary? (1986). Am Acad Child Psychiatry. (2):198-212.
21. Trepagnier C. (1996). A Possible Origin for the Social and Communicative Deficits of Autism. Focus on Autism and Other Developmental Disabilities. 11(3):170-82.
22. Gross TF. (2004). The perception of four basic emotions in human and nonhuman faces by children
with autism and other developmental disabilities. J Abnorm Child Psychol. 32(5):469-80.
23. Dawson G, Webb SJ, Carver L, Panagiotides H, McPartland J.(2004). Young children with autism show atypical brain responses to fearful versus neutral facial expressions of emotion. Dev Sci.7(3):340-59.
24. Grelotti DJ, Klin AJ, Gauthier I, Skudlarski P, Cohen DJ, Gore JC, Volkmar FR, Schultz RT. (2005). fMRI activation of the fusiform gyrus and amygdala to cartoon characters but not to faces in a boy with autism. : Neuropsychologia. 43(3):373-85.
25. Ghaziuddin M, Ghaziuddin N, Greden J (2002). Depression in persons with autism: implications for research and clinical care J Autism Dev Disord. 32(4):299-306.
26. Gillott A, Furniss F, Walter A. (2001). Anxiety in high-functioning children with autism. Autism. 5(3):277-86.
27. Ghaziuddin M, Weidmer-Mikhail E, Ghaziuddin N. (1998). Comorbidity of Asperger syndrome: a preliminary report. J Intellect Disabil Res. 1998 Aug;42 (Pt 4):279-83.
28. Gadow KD, DeVincent CJ, Pomeroy J, Azizian A. (2004). Psychiatric symptoms in preschool children with PDD and clinic and comparisonsamples. J Autism Dev Disord .34 (4):379-93
29. Trepagnier C, Sebrechts MM, Peterson R. (2002). Atypical face gaze in autism. Cyberpsychol Behav. 5(3):213-7.
30. Lord C, Rutter M & Le Couteur A. (1994). Autism Diagnostic Interview-Revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders.J Autism Dev Disord. 24(5):659-85.
31. Klin A, Jones W, Schultz R, Volkmar F, & Cohen D. (2002). Visual fixation patterns during viewing of naturalistic social situations as predictors of social competence in individuals with autism. Arch Gen Psychiatry 59(9):809-16
32. Orsmond GI, Krauss MW, & Seltzer MM. (2004). Peer relationships and social and recreational activities among adolescent s and adults with autism. Journal of Autism and Developmental Disorders 34:245-55.

Contact

Cheryl Y. Trepagnier, Ph.D.,
The Catholic University of America,
Washington, DC
USA
1 (202) 319-5780 (voice)
1 (202) 319-6162 (fax)
trepagnier@cua.edu

VR for Blood-Injection-Injury Phobia

B. K. Wiederhold[1,2], M. Mendoza[1], T. Nakatani[1], A. H. Bullinger[3], M. D. Wiederhold[1]

[1] Virtual Reality Medical Center, San Diego, California
[2] Interactive Media Institute, San Diego, California
[3]COAT-Basel/UPKBS, University of Basel, Switzerland, Department of Psychiatry

Abstract: *Virtual reality (VR) exposure therapy has been shown to be successful in treating many types of specific phobias which are mostly visual in nature. However, limited research has been completed on the use of VR therapy for Blood Injection-Injury (BII) phobias, one of the subtypes of Specific Phobia listed in the DSM-IV TR. Since BII phobia may operate by some tactile component, it may respond differently to VR therapy compared to other categories of specific phobias that are largely visually activated. This paper discusses initial development and results from a study on both subjective and objective arousal elicited by a prototype virtual world which has been developed to treat those with BII phobia. The present study evaluated the responses of 20 healthy, non-phobic male and female participants to VR blood and injection stimuli. Initial results are positive and show that the VR world delivers appropriate cues to elicit physiological and self-reported arousal when exposed to the injection scenarios. Correlations between self-reported anxiety and physiological arousal confirm that individuals experiencing greater symptoms of fear in conditions involving blood or injections will exhibit more intense arousal from the virtual stimuli than those who experience reduced symptoms. Findings suggest that the virtual world is an effective method of cue exposure for individuals who experience anxiety in situations related to blood and injections. Future research on the use of VR exposure therapy in the treatment of BII phobia is warranted.*

INTRODUCTION

The DSM-IV TR classifies phobias into three groups: 1) Agoraphobia, 2) Social Phobia, and 3) Specific Phobias. The further subdivision within Specific Phobias is: 1) Blood-Injection-Injury (BII), 2) Animal, 3) Natural Environment, 4) Situational, and 5) "Other". [1] Although VR exposure therapy has been used successfully for more than a decade to treat phobias; including specific phobias, panic disorder and agoraphobia, and social phobia [(4-13)]; only one study has attempted VR usage for injection phobia.[2]

Those who suffer from BII phobias may fear either the sight or the pain of the injection and often begin avoidance of any situation which may cause exposure to an injection, such as donating blood or going to the doctor. In extreme cases, the phobic may even begin to fear driving past a hospital.[3] Because BII phobia involves not only visual stimuli which elicit the phobic response, but also tactile stimuli; it may differ from other specific phobias in how it will respond to VR. In the previous injection study, it was found that VR could be used to successfully elicit subjective (measured with Subjective Units of Distress (SUDs ratings) and physiological arousal (measured with heart rate (HR)) in those with needle phobia, however, the results indicated that the addition of tactile stimuli would have proven to be more advantageous. In addition, the previous study presented the VR environment via a desktop display instead of a more immersive head-mounted display (HMD). [2] The present study, therefore, sought to investigate elicitation of arousal via a HMD VR system to be used in treating those with BII phobias. As an initial first step, however, we have sought to establish a baseline with those who do not meet the DSM-IV TR criteria for a BII phobia in order to use this arousal level as a baseline comparison for phobic participants exposed to the VR world.

MATERIALS AND METHODS

Participants

Twenty healthy, non-phobic participants (13 females and 7 males) from the San Diego area were recruited for this study. Their mean age was 27 ± 10, ranging from 20 to 54 years of age.

Virtual World

The low cost VR system was developed to be used on a personal computer (PC) platform with a HMD and tracking system so that the participant could explore the world via head tracking as well as navigation provided via a joystick. The virtual world was modeled after an outpatient clinic in La Jolla, CA and is almost an exact replica of the real life structure. Participants can navigate through the clinic's entrance, lobby, waiting room and exam rooms. Exam rooms are filled with typical phlebotomy lab paraphernalia, including vials of blood. In one of the exam rooms, the participant may sit down and have a "nurse avatar" administer an injection. This is viewed in first person, as if the participant is seated in the exam room chair and viewing his arm while receiving the injection.

Measurements

Objective physiological measures and subjective self-report data were collected from each participant. Physiological data consisted of heart rate and multiple respiration measures collected using VivoMetric's wireless Lifeshirt system; and heart rate, skin conductance and peripheral skin temperature data collected using J & J Engineering's C2 device. Physiological data was collected at baseline and continuously in real-time throughout exposure to the virtual world. Self-report data consisted of a Fear Questionnaire, a Blood Injection Symptoms Scale (BISS), a State Blood Injection Symptoms Scale (S-BISS), and a Post-Experience Questionnaire. The Fear Questionnaire and BISS were administered before baseline, the S-BISS was administered pre- and post-VR exposure, and the Post-Experience Questionnaire, which included questions on presence and simulator sickness, was administered after VR exposure.

Design

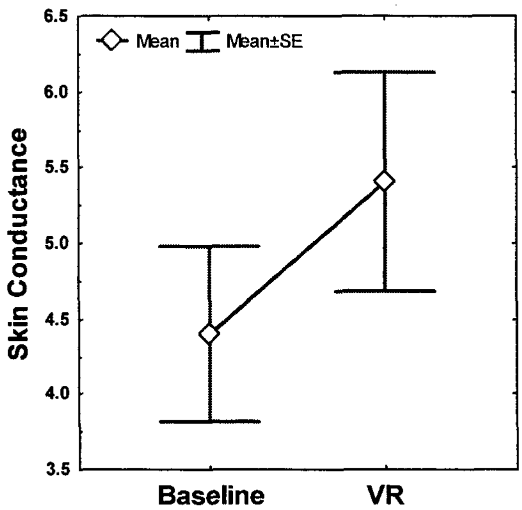
Ten (10) participants were randomly assigned, using a random numbers table, to Group A and 10 were randomly assigned to Group B. Group A was verbally instructed to navigate through the virtual clinic to a specified exam room where they would be seated but was not informed that they would be "receiving an injection". Group B was given the same instructions, but was also notified that they would receive an injection. Outcome measures were analyzed between groups to determine effect of instructions on anxiety (e.g. anticipatory anxiety).

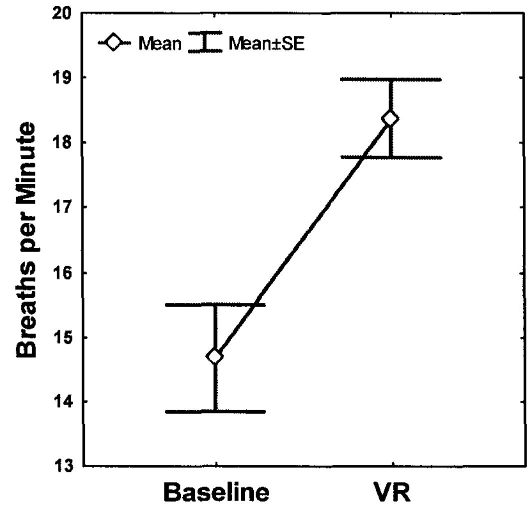
All 20 participants provided consent before completing the pre-test questionnaires. All participants completed a 3 minute baseline during which physiological measures were continuously collected. After baseline, participants completed the S-BISS and each group (A and B) received their respective instructions. Participants navigated the virtual world for 3 minutes and physiological data was collected throughout. During VR exposure, investigators recorded time markers, indicating when the injection was received by each participant. After VR exposure, participants completed the post-test questionnaires and subjective feedback was collected by investigators.

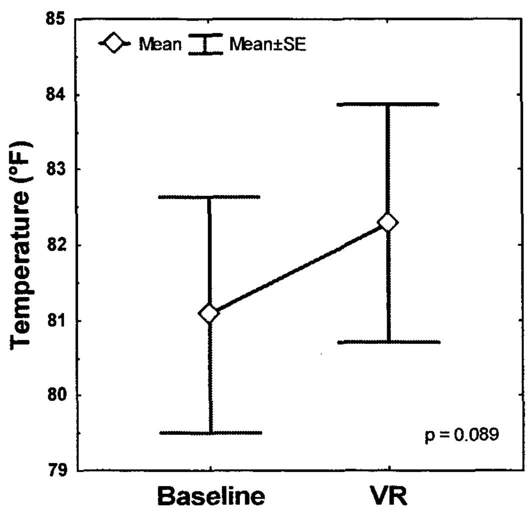
RESULTS

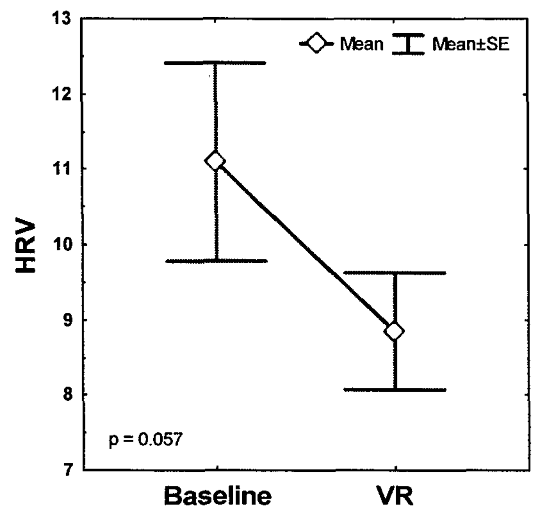
Physiological data from both conditions (A and B) was averaged and differences between baseline and VR were compared using a paired t-test (a = 0.05). Analyses indicated a significant increase in skin conductance (df = 1, 17; p = 0.018) and respiration rate (df = 1, 18; p = 0.0003) during VR. Temperature also increased during VR, but the difference was not statistically significant (df = 1, 18; p = 0.089). Combined group data exhibited a decrease in HRV (df = 1, 18; p = 0.057) and LF (df = 1, 18; p = 0.099) during VR, but neither difference was statistically significant. T-tests determined that differences in heart rate (df=1, 18; p=0.631), VLF (df = 1, 18; p = 0.672) and HF (df = 1, 18; p = 0.0442) measurements were not significant.

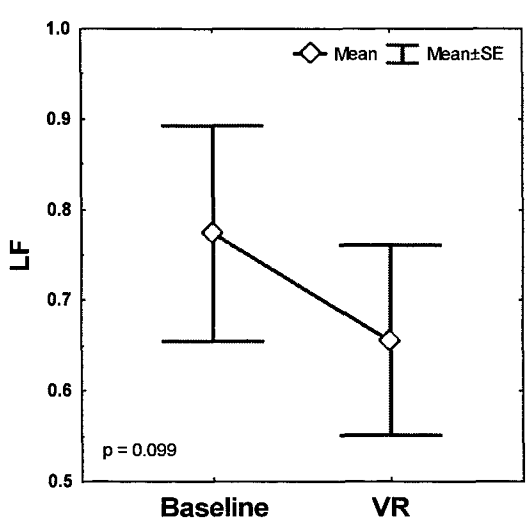
Combined group data from VR exposure was averaged into three distinct segments and analyzed; period before injection (VR1), injection



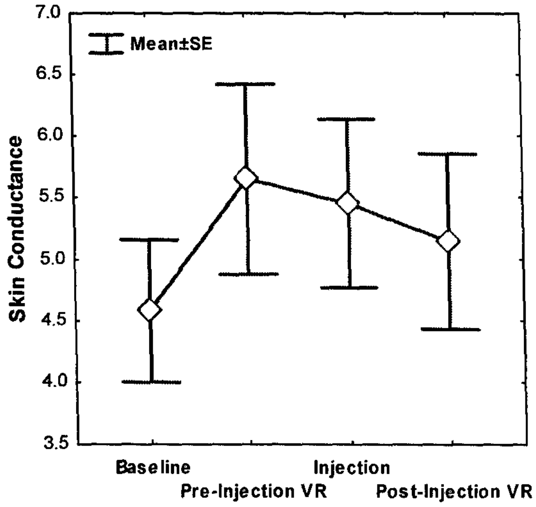


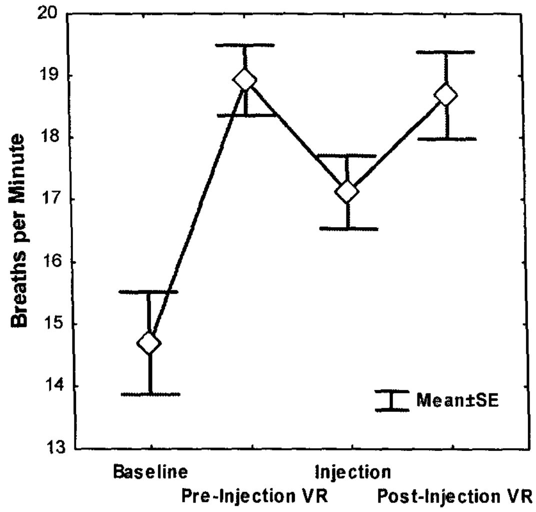


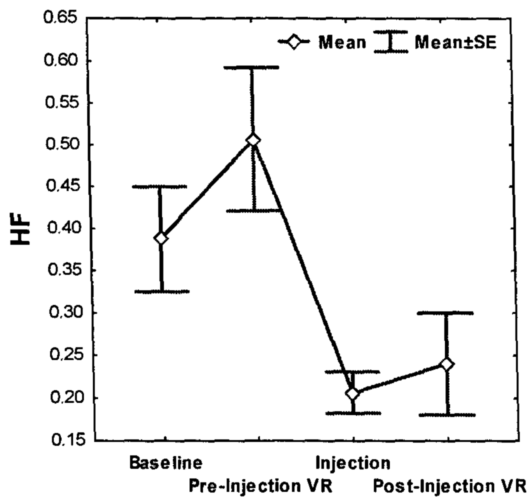


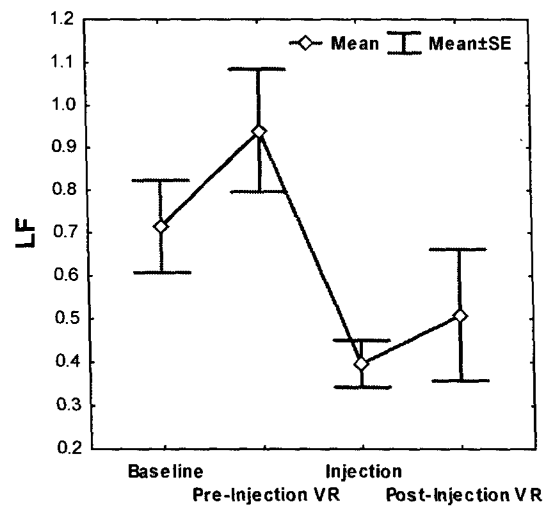


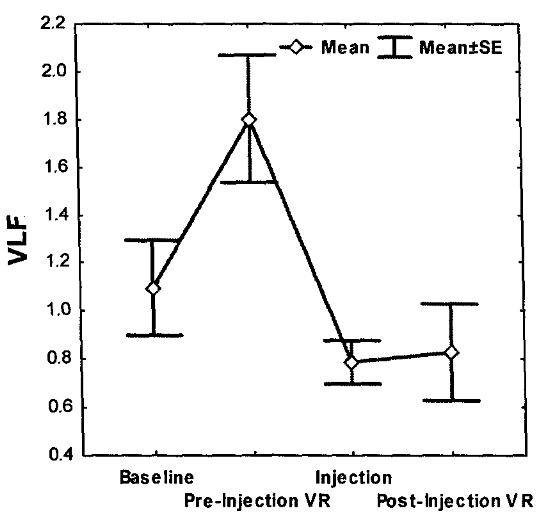
(VR2), and period after injection (VR3). A repeated measures ANOVA analysis of baseline and each VR segment revealed a significant increase in skin conductance from baseline during VR1 and VR2. Skin conductance also increased during VR3, but the change from baseline was not significant. A similar analysis of respiration rate indicated that BPM (breaths per minute) during baseline was significantly lower than VR1 and VR3, but not significantly different from VR2 (df = 3, 51; $p<0.0001$). An analysis of VLF data revealed that VR1 was significantly higher than baseline, VR2, and VR3 (df = 3, 51; $p<0.0001$). Both HF (df = 3, 51; $p<0.0001$) and LF (df = 3, 51; $p = 0.0002$) data exhibited a statistically significant increase dur-





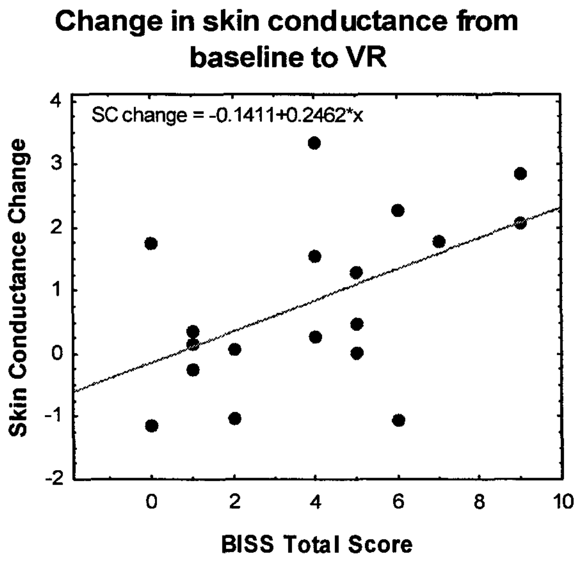






ing VR1 compared to VR2 and VR3. HRV was lower during each of the VR segments, indicating increased anxiety, but differences were not significant. Analysis of heart rate data indicated no significant difference between baseline and VR segments (df = 3, 51; p = 0.256 and df = 3, 51).

Total scores from the BISS were positively correlated to a change in skin conductance between baseline and VR exposure. Higher self-reported BISS totals were correlated to a greater change in skin conductance values between baseline and VR (r = 0.5411, p=0.025).

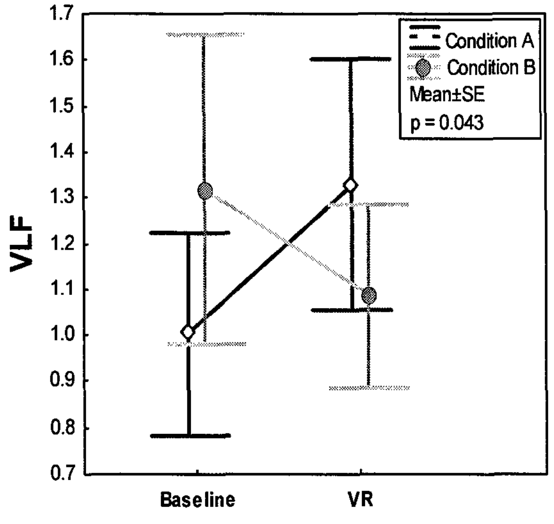


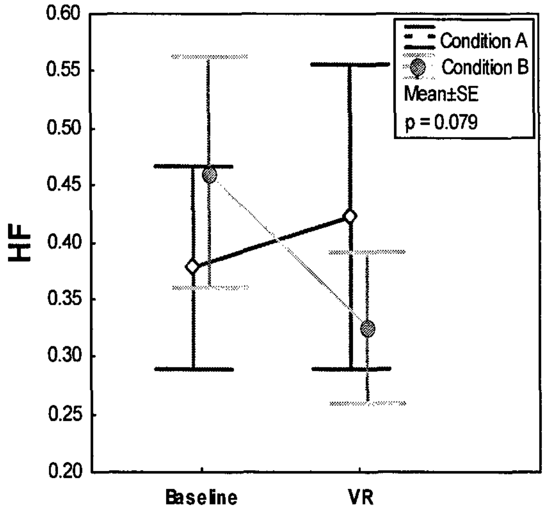
Repeated measures ANOVAs (a=0.05) were used to evaluate treatment effects. Analyses were conducted comparing baseline and VR as well as baseline, VR1, VR2, and VR3. Analysis of VLF between baseline and VR revealed significant interaction effects between conditions. HF data also demonstrated interaction effects, but the interaction was not found to be significant. An evaluation of baseline and VR segment averages revealed that Group B exhibited a larger increase in skin conductance values from baseline than Group A, but the difference was not significant. All other measurements indicated no significant interaction.

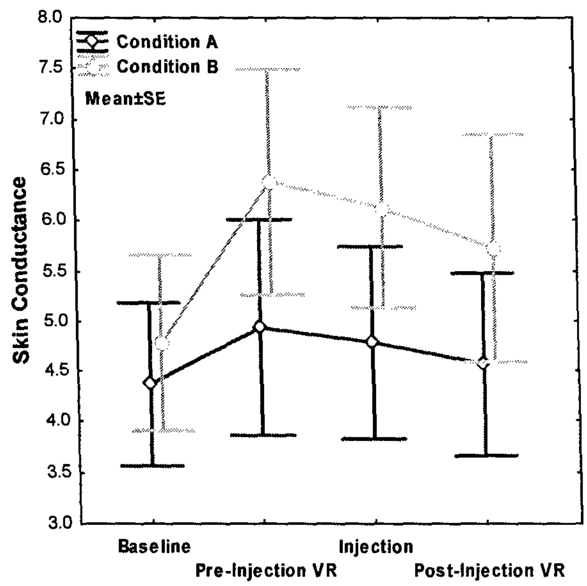
DISCUSSION

This study shows a general pattern of arousal during VR exposure. Skin conductance and respiration rate values increased from baseline to VR, indicating an increase in arousal due to VR exposure. The significant difference in skin conductance values of VR1 and VR2 (but not VR3) compared to baseline may suggest that the initial experience of the virtual world and the injection were the most stimulating segments of the VR exposure. This finding may also indicate that participants became relaxed after the injection, which resulted in a physiological response that was closer to baseline levels.

The significant change in skin conductance values during VR1 and VR2 may also be evidence of anticipatory anxiety exhibited by participants. Participants may have been stressed by the thought of visiting a hospital clinic and the thought of an injection (Group B only), which resulted in an initial increase in arousal (VR1 and VR2) and a subsequent stabilization of physiological response over time (VR3). This interpretation is supported by the differences exhibited between the two experimental conditions. While no statistically significant differences were determined, Group B revealed a larger increase in initial skin conductance values from baseline compared to Group A, which







may be due to greater anticipatory anxiety resulting from being told they would receive an injection. Group A was not notified of the injection and demonstrated less physiological arousal during initial exposure to the virtual world.

The respiration rate data demonstrates a different arousal pattern from the skin conductance results, but provides evidence of general arousal during VR exposure that is similar to the skin conductance data. The significant increase in BPM during VR1 and VR3 compared to baseline suggests that the virtual world produced a sustained state of heightened arousal in study participants. Unlike skin conductance data, BPM measures suggest that participant's physiology did not return to baseline levels after the injection, as BPM remained significantly higher than baseline at the beginning and end of VR exposure. The non-significant increase in BPM during VR2 can be explained by many factors and may provide evidence that participants held their breath while the shot was administered. Generally, lower BPM correlates to reduced arousal, but this association is inconsistent with the rest of the collected data, as VR exposure produced heightened arousal. Consequently, the lower respiration rate during the injection (VR2) may be better interpreted by behavioral factors, like holding one's breath, rather than state of arousal.

Heart rate increases were not found to be statistically significant between baseline and VR exposure. This has also been found in other VR studies which concluded that VR exposure may not be powerful enough to effectively trigger the behavioral activation system (BAS), measured here via heart rate, but does successfully trigger the behavioral inhibition system (BIS) which is measured here via skin conductance. There was, however, some significance found when looking at different frequency bands of heart rate variability, indicating that this measure may prove sensitive enough for future studies.

This study also shows a significant correlation between self-reported anxiety and objective physiological measures of anxiety. Participants who scored higher on the BISS indicated that they were generally more anxious about blood and injection stimuli (though not reaching levels diagnosable as phobic), which was consistent with the increase in skin conductance levels during VR exposure. This association suggests that participants who report greater symptoms of fear in situations involving blood or injections will exhibit a larger physiological response to the virtual world than those reporting reduced symptoms. This finding also reveals the efficacy of the virtual environment at providing potent blood and injection cues, and at generating an appropriate psychological and physiological stimulus response in participants who report symptoms of fear.

CONCLUSION

In this study we determined that the virtual cues produced significant changes in physiological arousal in normal non-phobic participants. Increased arousal levels resulting from VR exposure suggest that the virtual world is an effective method of cue exposure for individuals who report symptoms of fear in situations involving blood or injections. However, the results of this study are not conclusive and additional analysis must be completed to better determine the cause of the physiological changes that result from VR blood and injection stimuli. In addition, future research should evaluate the capacity to which the virtual environment can be generalized to larger populations, including phobic individuals.

FUTURE WORK

Future studies should include the presentation of the current VR world to those who meet DSM-IV TR criteria for BII phobia. In addition, comparison studies should include presentation via both a flat screen and a HMD to determine if indeed the more immersive HMD increases presence, immersion, and arousal. A comparison study should also be included to determine if tactile feedback done in reality which corresponds to the VR visual stimuli would increase initial arousal and possibly result in a more efficient method of treatment. Finally, given advances in wireless technology for physiological monitoring, it would be interesting to test participants in both the actual real world setting and compare results to those elicited in VR exposure.

REFERENCES

1. American Psychiatric Association: APA. (2000). Diagnostic and Statistical Manual of Mental Disorders Fourth Edition Text Revision. Washington, DC: American Psychiatric Association.

2. Hamza, S., Jones, N., Lesaoana, M., Blake, E., & Strauss, R. (2000). A first study of virtual reality exposure therapy in needle phobia. *Thesis Report*: October 2000.

3. Marks, I.M. (1969). Fears and Phobias. William Heinemann Medical Books Ltd.: London.

4. Bullinger, A.H., Roessler, A, Mueller-Span, F, (1998). "Three Dimensional Virtual Reality as a Tool in Cognitive-Behavioral Therapy of Claustrophobic Patients", Cyberpsychology and Behavior, 1 (2): 139-145.

5. James, LK., Lin, CY, Steed, A, Swapp, D, Slater, M (2003). "Social Anxiety in Virtual Environments: Results of A Pilot Study." CyberPsychology & Behavior. 6(3): 237-243.

6. Pertaub, D-P., Slater M., Barker, C. (2001). "An Experiment on Fear of Public Speaking in Virtual Reality." Medicine Meets Virtual Reality 2001, J.D. Westwood et al. (Eds.), IOS Press, 2001.

7. Vincelli, F., Anolli, L., Bouchard, S., Wiederhold, B.K., Zurloni, V., & Riva, G. (2003). "Experiential Cognitive Therapy in the Treatment of Panic Disorders with Agoraphobia: A Controlled Study." CyberPsychology & Behavior. 6(3): 321-328.

8. Vincelli, F., Choi, Y.H., Molinari, E., Wiederhold, B.K., & Riva, G. (2001). "A Multi-Center Study for the Treatment of Panic Disorder with Agoraphobia: The Experiential-Cognitive Therapy." In T. Scrimali & L. Grimaldi (Eds). Cognitive Psychotherapy toward a New Millenium, Kluwer Academic/Plenum Publisher: London.

9. Walshe, D.G., Lewis, E.J., Kim S.I., O'Sullivan, K., Wiederhold, B.K. (2003). "Exploring the Use of Computer Games and Virtual Reality in Exposure Therapy for Fear of Driving Following a Motor Vehicle Accident". CyberPsychology & Behavior. 6 (3): 329-334.

10. Wiederhold, B.K. (1999). "A comparison of imaginal exposure and virtual reality exposure for the treatment of fear of flying" [doctoral dissertation]. California School of Professional Psychology.

11. Wiederhold, B.K. (2001). "Overview of Virtual Reality Therapy." Proceedings of the 9th Annual Medicine Meets Virtual Reality Conference. January 24-27, 2001, Newport Beach, California.

12. Wiederhold, B.K. & Wiederhold, M.D. (2000). "Lessons Learned From 600 Virtual Reality Sessions." CyberPsychology & Behavior. 3 (3): 393-400.

13. Wiederhold, B.K., Wiederhold, M.D., (2005). Virtual Reality Therapy for Anxiety Disorders- Advances in Evaluation and Treatment. Washington, DC: American Psychological Association.

14. Wilhelm, F.H., Pfaltz, M.C., Gross, J.J., Mauss, I.B., Kim, S.I., and Wiederhold, B.K. (2005, in press). "Mechanisms of Virtual Reality Exposure Therapy: The Role of the Behav-

ioral Activation and Behavioral Inhibition Systems". Applied Psychophysiology and Biofeedback Journal.

Contact

Brenda K. Wiederhold
Interactive Media Institute
6160 Cornerstone Court East, Suite 161
San Diego, CA 92121
Ph: (866) 822-8762
Fax: (858) 642-0285

Working Things Out: A Therapeutic Interactive CD-Rom Containing the Stories of Young People Dealing with Depression and other Mental Health Problems

E. Brosnan, Dr. J. Sharry, Prof. C. Fitzpatrick

University College Dublin/ Mater Hospital

Abstract: *It is widely accepted that children and young people enjoy using computers. Seymour Papert[1] suggests that 'it is timely for school counsellors and child therapists to bridge the digital generation gap and innovate with computers in their work with children of the digital age. ' Working Things Out (WTO) was developed in response to the growing need for computer-based resources for adolescents in therapy. It is an interactive CD ROM/DVD developed as a means of engaging adolescents about mental health issues by giving them information in the form of animated personal stories told by other young people dealing with problems such as depression, bullying, eating problems and self-harm. The CD-ROM/DVD is accompanied by a manual for professionals on how to use the resource.*

With the help of therapists, and in collaboration with graphic designers, animators and multimedia professionals, the 11 young people who participated in the project told their stories, narrated in their own voice and illustrated by graphics and animation. 'Working Things Out' is currently being used as an educational and therapeutic tool with other adolescents at risk of mental health problems, both as a way of engaging young people to reflect about mental health issues and as a means of inviting them to tell their own story. The paper describes the background and development of the 'Working Things Out' project, including samples from the stories and a description of how the CD-ROM/DVD can be used in psychotherapy.

ACKNOWLEDGEMENTS

In developing this project we would like to acknowledge the work of Bernie McCarthy, Ciara Devine, Pilar Valencia, Hugh O'Neill, Peter McCormack and John Stapleton from the production team.

THERAPEUTIC STORY TELLING AND DIGITAL MEDIA

Telling and listening to stories is a fundamental human activity, both as a means of entertainment and communicating information. Whether we are listening to a personal anecdote, reading a novel or watching a soap opera, a 'good story' holds much greater appeal than a series of facts alone and is much more likely to engage our imagination and hold our attention. Personal stories that relate real-life accounts of peoples lives, and which have the mark of authenticity can hold a particular appeal to an audience, allowing special identification with the character and context. Further, personal stories can have great meaning to the storytellers as well as the listeners in that the act of telling the story can shape and define their lives.

As a result psychotherapists are very interested in personal stories. Psychotherapy can be conceived as process of inviting clients to tell and retell their life story from a variety of perspectives with the aim of reaching a coherent and meaningful narrative at the end.[2] Within a strengths-based approach to psychotherapy the process can be conceived as helping clients shift from initially self-limiting and problem-focused accounts of their lives to more positive and strengths-oriented accounts that are more liberating and empowering.[3,4] For example, a person may begin psychotherapy by telling the story of how he became depressed and how this damages his life and end therapy with a 'new' story of how he has coped with the depression and how this leads to new possibilities in his life. This is not simply a semantic differ-

ence: the act of retelling your story to an empathic listener, in a way that identifies new strengths-based 'plot lines' and that incorporates supportive 'characters' more centrally to the story, is in itself beneficial and transforming to ones personal identity.

Computers and digital media

Computers and digital media provide therapists with new means to engage clients and assist them in telling their life stories. Narrative structures and storylines are widely employed in many different types of digital media, including video game design, web-design, and e-learning. By including a narrative structure, this can increase the appeal for users and offer a context for creating meaning, thereby deepening their experiences of the information being presented. Abbe Don in an article entitled "Narrative and the Interface" argues that computers can play in modern society the role of the storyteller of oral cultures.[5,6] The computer becomes the processor of the "told" information, the user/viewer takes on the information and interprets it in a way that is meaningful to them.

Digital storytelling techniques are particularly relevant in the context of psychotherapy. The computer provides novel means of both *expressing and listening* to therapeutic stories. The computer facilitates the expression of the therapeutic story by allowing the incorporation of sound, image, animation as well as text and verbal communication in the telling. Equally the computer facilitates the listening to the story, by providing interactive interfaces and databases that allow the listener to pace the story to their own need and to make choices about what is relevant. The Working Things Out project aimed to build on these twin key potentials that are afforded by digital media in therapeutic storytelling.

WTO PROJECT RATIONALE AND BACKGROUND

The idea for the WTO project emerged during the 'Challenging Times' research study[6] which looked at the incidence of depression and other mental health difficulties amongst the12-15 year old population in secondary schools in the North Dublin City area. A subsequent qualitative study[8] engaged a smaller group of young people to share their stories of how they were coping and dealing with depression and other difficult life experiences. A key finding of the studies was the fact many young people in the community who suffered from depression did not access traditional professional mental health services.

The WTO project grew out of a desire to create an accessible means of providing mental health information as well as a means of engaging young people in professional services and psychotherapy. To ensure this was relevant to young people, participants from the study were invited to contribute to the making of the CD-ROM/DVD and to share their personal stories of dealing with a difficult life experience during adolescence. The inclusion of real young people's experiences in a story format makes the material much more real and relevant. A multimedia interactive CD-Rom was chosen as the format for the collection of stories as this motivated the young people tell their story, (many were keen to gain experience of creatively using digital media creatively) and also provided an engaging 'youth centred' format for future users.

The project was developed as a partnership between the Department of Child and family Psychiatry in the Mater Hospital, the charity Parents Plus (which will distribute the CD-Rom) and the Therapeutic Technologies Group in Media Lab Europe.

Development

Young people aged 13 to 16 who attended the Mater Child and Adolescent Mental Health Service and/ or who participated in the Challenging Times research study above were invited to participate in the project. Specifically, they were asked to share their experience and stories in order to make a CD-ROM to help young people overcome problems in their lives. The altruistic nature of the project appealed to many of them, as much as the possibility of working with multimedia to tell their stories. After a series of general focus groups, eleven young people were selected to take part. The problems the young people were dealing with ranged from more 'everyday' issues such as bullying, conflict with

parents and school problems to more specialist problems such as self-harm, bereavement, obsessive-compulsive disorder, and eating problems.

To develop a 'script' for the stories, each young person attended a series of individual meetings with a therapist who through a process of listening and clarifying helped the young people begin to tell their story in a structured format. This structure focused not only on their experience of having a problem, but also how they coped and what supports and resources helped them. The final scripts for the short movies were co-authored by therapist and young person. Some young people were able to write the majority of the script themselves and others needed more support (e.g. the therapist would transcribe the main points from a recorded interview and re-read to the young person for approval).

The young people were also involved in the creative aspects of the production. Some were involved in the storyboarding of the scenes, the development of the graphics and the choice of images. Alongside the individual sessions, several workshops were conducted with the young people on animation, graphics, photography and digital audio. This helped each young person take ownership of his/her story both in its script and in how it would be animated and represented. A key aspect of this project was to ensure that the stories are personal and meaningful to the participating adolescents and their families. The introduction to the stories was written in conjunction with the young people and is as follows:

Welcome to 'Working Things Out' the stories of 11 young people who have gone through some difficult life experiences. By sharing our stories, our feelings and our ways of coping with our problems, we hope that others who might be going through a similar hard time will be reminded that they are not alone and that there are many different things you can do to make things better.

Telling our stories definitely made us feel better, it was good to get stuff off our chests. We hope that the very real experiences you hear will be a source of support and learning for you. Our stories are ongoing and not all our problems have gone away but the way we understand and deal with them has changed. While we don't have all the answers, we might have some useful messages and information.

In developing the project we were keen to ensure that the final accounts were confidential meaning that we would not use any identifying material such as pictures or real names. Thus, in order to maintain the authenticity of the project, the young people themselves provided the 'voice over' recording to a script that had been co-written with the therapists. The final production includes ten mini-movies of the young peoples' stories and one recorded song written by one participant who preferred to share his experiences in lyrics and music.

Case Example – Michelle's Story

To illustrate the content and purpose of WTO we reproduce below the opening text for Michelle's story who had been referred to an adolescent mental health service due to her eating problems.

<u>'Shocked Into Reality' - Other kids at school were calling me fat.</u>

Other kids at school were calling me fat. I was only ten at the time. I started feeling fat and paranoid and thought everybody was looking at me. Like if I went shopping with the other girls in my class and one of them said to another " oh those jeans would fit you" I would think it was directed at me like, that she meant they wouldn't fit me. I used to think that comments like that were aimed at me, though they wouldn't be in reality. I started skipping breakfast purposefully and would try not to eat much at lunch. Like I'd eat half a cracker at break and the other half at lunch. I used to think that if I ate any more I'd get fat. Then I started exercising, doing sit ups and making a big effort in PE so I'd be thinner.

This was going on for a few months and my Mam noticed I was losing weight.

She took me to the doctor. The doctor talked to me about my food intake and told me I should be eating more. My Mam and my sister were telling me the same thing but I didn't listen to any of them. I still wanted to be thinner. I didn't

think I was losing weight myself. When I'd look in the mirror I used to see myself as bigger than I actually was. My friends started saying I was too skinny but I didn't believe them either. I would feel the hunger in my stomach but I ignored it because I was determined not to eat and I'd feel the cold even when it was sunny out.

Michelle's story is played as a movie and illustrated with line graphics that support her narration (fig 1). In later parts of the story she goes on to say how she and her mother finally sought help for her difficulties. A turning point comes when in her own words she is 'shocked into reality' by a medical report which highlights just how underweight and undernourished she is. At the end of the story she relays how she currently maintains her eating and health.

USING WTO AS AN EDUCATIONAL GUIDE WITH YOUNG PEOPLE

As well as being beneficial to the participants, the WTO CD ROM has been designed as an educational guide for young people (and their families) who are experiencing similar problems. The current version of "Working Things Out" is designed to be used in a facilitated way by professionals working with young people either individually or with a small group of adolescents, in either a mental health or school setting. The aim is that on viewing the stories adolescents may feel a resonance or empathy with the story teller helping them feel 'not alone' if similar issues affect them. In addition, viewing the story could provide an important focal point for discussion and also engage the adolescent to open up and share their own experience if that is appropriate.

The final version of the CD-ROM contains an introduction and a panoramic interface (fig 2), representing a street, which they can scroll across left and right to view the silhouette of eleven young people whose pseudonyms are given along with a title of their story. Selecting a story allows it to be played in a linear fashion from beginning to the end, with the options of pause, fast forward and rewind. The stories are illustrated by graphics and animation and narrated by the personal voice of the young person. In addition, each story is punctuated by several 'information points' which provide a commentary on some of the key points raised in the story as well as some sample questions for professionals to use to promote reflection and to facilitate the personalisation of the material. For example, the opening information point for Michelle's story above is as follows

Pressure to be thin
Like Michelle, many young people feel self-conscious about their appearance and body shape and feel under pressure to look a certain way and to be a certain weight. For Michelle it became a problem and she began to see herself as 'bigger than she actually was', and she

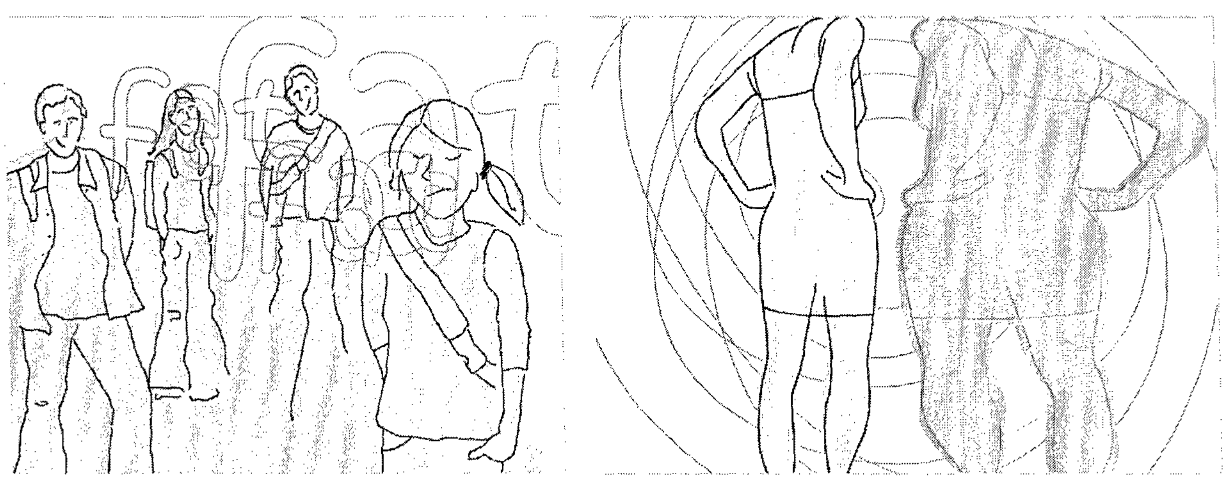


Figure 1. Graphics from Michelle's Story

Figure 2. Panoramic Opening Interface

started controlling her food intake to the point where she ignored the hunger and cold. Like many people, Michelle was using control over food to cover up the upset, loneliness and sadness she was feeling. However, when a young person begins to ignore the reality of his/ her weight loss and discomfort and get obsessed about limiting food intake he/she is in danger of developing a serious eating disorder.

Questions

How real are the pressures on young people to diet so as to be thin?

If you were a friend of Michelle's what could you do to help her?

DISCUSSION AND EVALUATION

Following completion of the Working Things Out Project the young people who participated in it took part in an evaluation of the process. They all reported it as a beneficial experience. Aside from it being therapeutic for them to tell their story in a creative form, it has also provided them with the opportunity to learn new skills and to use multimedia. For many, participation has also had positive impacts on their families. When parents have reviewed their children's story it has often opened up family communication. One mother described how proud she was of what her daughter had achieved and reviewing the story became a special moment of connection for them both. Finally, participation in the CD Rom has copper-fastened, for many of the young people, their coping skills and survival strategies. They have moved from being 'recipients' of mental health information to being 'teachers' and those who provide it.

The Working Things Out CD-Rom/DVD and Resource Manual was launched in February 2005. The package was field tested with young people attending the Mater Hospital both individually and in small groups.

Professionals who have used the stories with young people have found it a useful engagement tool with young people, inviting them to begin to talk about their own experience, particularly when the viewed story resonates with the particular experience of the adolescent. Initial cautions are to ensure that the story shown is relevant to the young persons concerns and context.

It is our experience that computers and multimedia can positively engage young people in coming to therapy. There is anecdotal evidence to suggest that the initial 'resistance' to coming to therapy often expressed by adolescents dissipates when the computer is used as an engagement tool.

FUTURE DEVELOPMENTS

A further project has now developed out of the Working Things Out research. As part of the Therapeutic Technologies Research Group (University College Dublin/Mater Hospital) we are current developing "Transforming Stories" which is a database driven multimedia storytelling tool delivered both online and on stand alone platform. The software currently being developed will allow the user to choose a story template and build up the story plot using customisable characters and background scenes adding in their own voiceover and animation. The user has a drag and drop facility for placing story objects and further features such as positioning tools, playback and story editing. Other options include building from seed stories where they can change the plotline and add in their own characters and dialogue. In the method, the therapist introduces the idea of making a story and shows examples of what is possible using the software. It can be a story tailored to a problem that needs resolution or a general story that brings about some positive change in the storyline. A key therapeutic feature is a notebook facility where the child and

therapist keep a log of their thoughts on the process and their analysis of the story. This allows for reflection and gives the therapist the opportunity to prompt new ideas for problem solving. Finally they can upload and share their stories to an online community. Over time it is hoped that a large database of stories will be build up as a shared resource that can be made available to young people struggling with problems as a source of support and reliable information.

REFERENCES

1. Papert, S. (1996) "The Connected Family: Bridging the Digital Generation Gap", Atlanta, USA: Longstreet Press.
2. White, M., & Epston, D. (1990). *Narrative means to therapeutic ends.* New York: Norton.
3. Sharry, J. (2001). *Solution Focused Groupwork.* London: Sage.
4. Sharry, J. (2004). *Counselling children, adolescents and families: A strengths-based collaborative approach.* London: Sage.
5. Ryan, T., & Walker, R. (1993). *Life Story Work.* London: British Agencies for Fostering and Adoption.
6. Ryan, M.-L. (2001). Beyond Myth and Metaphor - The Case for Narrative in Digital Media. *The International Journal of Computer Game Research, 1*(1).
7. Lynch, F., Mills, C., Daly, I., & Fitzpatrick, C. (in press). Challenging Times: A Study To Detect Irish Adolescents At Risk Of Psychiatric Disorders And Suicidal Ideation. *Journal of Adolescence.*
8. Fitzpatrick, C., & Sharry, J. (2004). *Coping with Depression in Young People - A Guide for Parents.* Chichester: Wiley.

Gardner, R. A. (1993). *Story-telling in psychotherapy with children.* New Jersey: Aronson.

Philips, R., Brewer, D., & Stavrianoudakis, J. (1993). *Gem of the First Water: An Oral Story for Helping Teens Make Good Decisions.*: Resource Publications

Schafer, C. E., & O'Connor, K. J. (Eds.). (1983). *Handbook of play therapy.* Toronto: Wiley

Contact

Dr John Sharry
Dept. of child and family psychiatry
Mater Hospital
Dublin 7 Ireland.
Tel: +353 1 803 4793
Email Eileen.brosnan@tcd.ie
www.workingthingsout.ie

Original Research

Assessment of Emotional Reactivity Produced by Exposure to Virtual Environments in Patients with Eating Disorder

M. Ferrer-Garcia & J. Gutiérrez Maldonado, PhD.

University of Barcelona

Abstract: *This paper describes the effectiveness of virtual environments to elicit emotional responses in eating disordered patients. This study is part of a wider research project analysing the influence of the situation to which subjects are exposed on their performance on body image estimation tasks.*

Though it seems self-evident that there is a close relation between eating disorders (ED) and altered body image, in the literature on the subject no clear association has in fact been established, and indeed the results of the studies are often contradictory or inconclusive. A number of hypotheses have been proposed to account for these results. Some authors have stressed the fact that body image may be to a certain extent more a state than a trait and may change according to situational or emotional variables. Several studies have analysed the possible impact of exposure to specific objects or situations on the stability of the body image.

In this study we designed several virtual environments that were emotionally significant for subjects with ED in order to generate different levels of anxiety and variations in mood. Unlike conventional methods (real exposure to the situation, exposure to photographs, exposure via guided imagination, and so on), virtual reality exposes subjects to interactive three-dimensional environments that simulate real situation. These environments have ecological validity but also permit strict control over the variables and the recording of data. Virtual reality offers many of the advantages of the conventional methods mentioned above, and also overcomes many of their drawbacks.

Thirty female patients with eating disorders were exposed to six virtual environments: a living-room (neutral situation), a kitchen with high-calorie food, a kitchen with low-calorie food, a restaurant with high-calorie food, a restaurant with low-calorie food, and a swimming-pool. After exposure to each environment the STAI-S (a measurement of state anxiety) and the CDB (a measurement of depression) were administered to all subjects.

The results showed significantly higher levels of state anxiety in the kitchen with high-calorie food ($F=13.120$; $p = 0.001$), the restaurant with high-calorie food ($F = 14, 954$; $p = 0.001$) and the swimming-pool ($F = 4.230$; $p = 0.049$) than in the neutral environment. Analysing the scores for depression obtained on the CDB, significant differences again appeared between the high-calorie food environments ($F = 7.187$; $p = 0.012$ in the kitchen and $F = 5.933$; $p = 0.021$ in the restaurant) and the neutral environment. In the high-calorie food situations patients with ED showed a more depressed mood.

Virtual reality thus appears to be a valid instrument particularly useful for simulating everyday situations that may provoke emotional reactions such as anxiety and depression, in patients with ED. Virtual environments in which subjects are obliged to ingest high-calorie food provoke the highest levels of state anxiety and depression. Previous studies have shown the capacity of VR to elicit states of anxiety in patients with other pathologies too.

INTRODUCTION

During the last four decades, body image disturbances have been considered one of the main features of eating disorders. Nevertheless, the published literature has not established a clear association between Eating Disorders (ED) and altered body image, and found results have been often contradictory or inconclusive.[2, 8, 18, 19, 20] In order to explain these results some authors have stressed the fact that body image may be considered more a state than a trait[20,21, 24] and may change according to situational or emotional variables. Several studies have analysed the possible impact of exposure to specific objects or situations on the stability of the body image.[1,3,6,7,9,10] These studies suggest that body image, or some of its components, can indeed be understood as a state.

Following the same research line, we want to study whether exposure to virtual environments produces variations in the estimation of body image and whether anxiety exerts a mediating role in this relation. With this aim, we designed several virtual environments that were emotionally significant for subjects with ED in order to generate different levels of anxiety and variations in mood. This paper describes the first stage of the project, in which we evaluate the effectiveness of these virtual environments to elicit emotional responses in ED patients.

In the area of eating disorders, virtual reality has been used for the assessment and treatment of body image disorders[11-16]. Perpiña and co-workers (1999) compared the efficacy of a traditional body image disorders treatment program with the efficacy of a treatment program that included virtual exposure. Patients treated with virtual reality showed a significantly major recovery in body image disorder and in depressive and anxious sintomathology.

These studies show virtual reality as a valuable technology for psychopathological assessment and treatment. One of the main advantages of this technology is its capability of simulating real situations (high ecological validity) and allowing a severe control of the variables, at the same time. So, virtual reality offers many of the advantages of the conventional methods (real exposure to the situation, exposure to photographs, exposure via guided imagination, and so on), and also overcomes many of their drawbacks.

It is accepted that patients with ED show anxiety on seeing high-calorie food and in situations in which their body is displayed or in which they come into contact with other people[17]. In our design of the environments we incorporated these two variables in the following conditions: Presence of food (No food, high-calorie food and low-calorie food) and presence of other people (No other people present and other people present). The combination of the two variables gives rise to a repeated measures design (2x3) with six experimental conditions or virtual environments: The living-room or neutral environment (no food and no other people present), the kitchen with low-calorie food (low-calorie food and no other people present), the kitchen with high-calorie food (high-calorie food and no other people present), the restaurant with low-calorie food (low-calorie food and other people present), the restaurant with high-calorie food (high-calorie food and other people present) and the swimming-pool (no food and other people present).

This study aims to assess the effectiveness of virtual environments to provoke emotional reactions (anxiety and depressed mood) in patients with ED. The following hypotheses are considered: the first one, if food constitutes an aversive, anxiety-provoking stimulus for people with ED, exposure to virtual situations in which subjects must eat different types of food (high or low calorie) will increase their level of anxiety and depression; the second one, if subjects with ED experience higher levels of stress in social situations and situations that involve scrutiny by others, exposure to these types of situation will increase their level of anxiety and depression.

MATERIALS AND METHODS

Procedure

In a *first stage*, all the subjects of the sample filled two self-report questionnaires, the EDI-2 (Eating Disorders Inventory) and the STAI-T (Trait Anxiety Inventory). Each subject was then measured and weighed individually in order to calculate their body mass index (BMI). The

measurements were performed after the questionnaires were completed to avoid the possible influence on the test scores of anxiety caused by the measuring and weighing. Finally, a form was filled out for each subject specifying their age, weight, height and BMI, type and course of the disorder and severity of symptoms. In a *second stage* the six virtual environments were randomly administered. In the interval between the presentation of each environment, the subject was administered the STAI-S (State Anxiety Inventory) and the CDB (a depression scale). Both tests were computerized using a program that integrates them in the sequence of virtual environments, and records and saves the data.

Subjects

The sample comprised 30 women with a prior diagnosis of eating disorder (17 with anorexia nerviosa, 11 with bulimia nerviosa and 2 with non-specific eating disorder) and with ages ranging from 16 to 32 (mean = 20.57 and standard deviation = 4.15). The patients were from hospital centres and private clinics in Barcelona: the Hospital Germans Tries i Pujol, the Hospital de Sant Juan de Déu, the Clinica Labor and the Centro ABB.

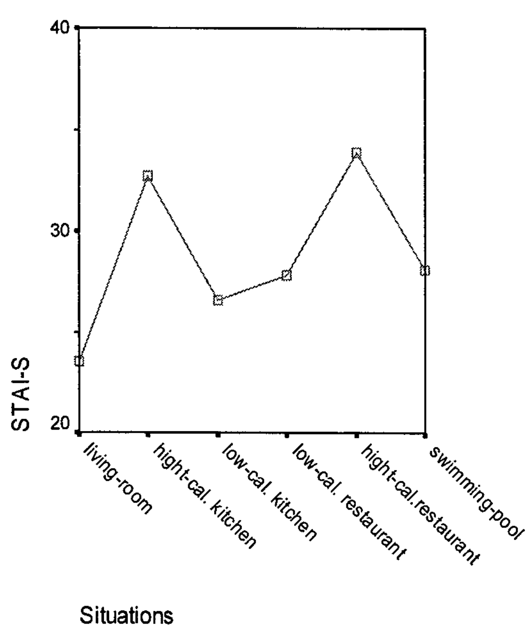


Figure 1. STAI-S scores obtained after visiting each virtual environment

Instruments

EDI-2 *(Eating Disorders Inventory-2).* D.M. Garner. Spanish adaptation by S. Corral, M. Gonzalez, J. Pereña & N. Seisdedos (1998): self-report questionnaire for the evaluation of symptoms that normally accompany anorexia nervosa and bulimia nervosa. The questionnaire offers scores on 11 scales: Drive for Thinness, Bulimia, Body Dissatisfaction, Ineffectiveness, Perfectionism, Interpersonal Distrust, Interoceptive Awareness, Maturity Fears, Asceticism, Impulse Regulation and Social Insecurity.

STAI *(Stait-Trait Anxiety Inventory).* C.D. Spielberger, R.L. Gorsuch and R.E. Lushene. Spanish adaptation by N. Seisdedos (1988): anxiety questionnaire comprising two separate self-report scales that measure two independent concepts of anxiety, a) as a state and b) as a trait.

CDB *(The Barcelona Depression Questionnaire).* J. Gutiérrez-Maldonado and M. Mora-Bello (2000): Self-report instrument for measuring variations in depressed mood. It comprises 23 items, each one with a visual-analog scale with an adjective describing a mood written at the top: subjects mark the line corresponding to their experience of this mood, ranging from "I don't feel like this at all now" to "I feel completely like this now". The items were taken from the diagnostic criteria for major depression from the nosological classification of the DSM-IV and were presented in the questionnaire in the same order as the criteria. All the items are formulated in the same direction.

Virtual environments: six virtual environments (living-room, kitchen with low-calorie food, kitchen with high-calorie food, restaurant with low-calorie food, restaurant with high-calorie food, and swimming-pool) developed using the virtual reality software 3d Studio Max5.1 and programmed using the Lingo language with the Director software.

RESULTS

Using repeated measures analysis, we compared subjects' scores on the STAI-S and the CDB after visiting each of the five experimental environments with the score obtained after visiting the neutral environment (the living-room).

The results showed significantly higher levels of state anxiety in the kitchen with high-calorie food (F=13,120; p = 0,001), the restaurant with high-calorie food (F = 14, 954; p = 0,001) and the swimming-pool (F = 4,230; p = 0,049) than in the neutral environment (figure 1).

Analysing the scores for depression obtained on the CDB, significant differences again appeared between the high-calorie food environments (F = 7.187; p = 0.012 in the kitchen and F = 5.933; p = 0.021 in the restaurant) and the neutral environment. In the high-calorie food situations patients with ED showed a more depressed mood (figure 2).

Finally, no interaction was found between the variables "food" and "people". There were significant differences only on the level of state anxiety (STAI-S) comparing low-calorie and high-calorie food environments (F = 15,262; p = 0,001). No differences were found between environments with people and those without, or when analysing the combined effect of these two variables. The same pattern of results appears on analysing the results of the CDB: the only effect is exerted by food.

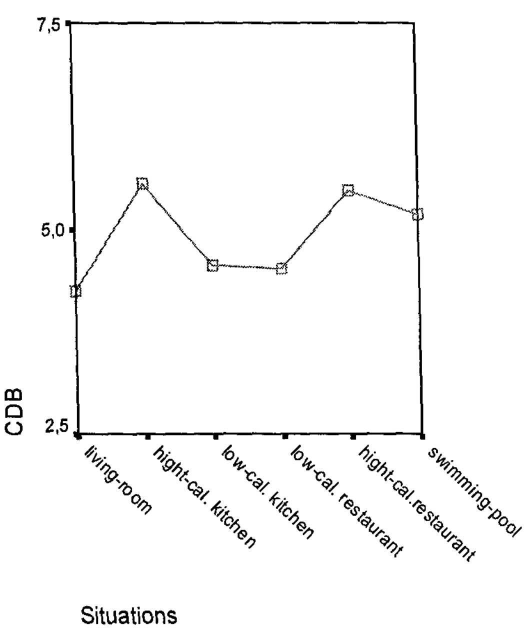


Figure 2. CDB scores obtained after visiting each virtual environment

DISCUSSION

According to the first hypothesis, virtual environments in which subjects have to eat high-calorie food (the kitchen and restaurant with high-calorie food) caused significant increases in the levels of anxiety and more depressed mood compared with the neutral situation (the living-room). Subjects with ED show negative reactivity to high calorie foods due to their fear of gaining weight. Other authors as Heilburn and Flodin (1989) have already stressed the aversive effect that food has on patients with ED.

In reference to the second hypothesis, we aimed to determine whether exposure to virtual environments that simulate social situations increases the level of state anxiety and produce a more depressed mood in people with ED. Only the swimming-pool situation significantly increases the level of anxiety compared with the neutral environment. The high level of anxiety shown after visiting this virtual environment reflects the importance that patients with eating disorders attribute to their body image and to the evaluation that others may make of it. In this environment subjects wear bathing-suits and are exposed to attractive young people also wearing bathing-suits, so aspects such as body dissatisfaction and negative social comparison contribute to raise their level of anxiety. Thompson and Chad (2002) affirm that subjects with negative perception and thoughts regarding their body shape are usually worried about how others see them; this is clearly the case of patients with ED. The authors add that these subjects may try to avoid situations in which their body is exposed to others, as is the case of the swimming-pool.

One of the aims of the design of the virtual environments was to make the effects of food and people additive, so we expected the restaurant high-calorie environment to provoke the highest levels of reactivity in subjects because of the presence of people and the presence of high-calorie food at the same time. However, though there was no interaction between the variables, the presence or absence of people had no significant effect in the restaurant situation. Food was the only effect that was significant in all situations, for both anxiety and depression. This

means that the subject's exposure to a situation with low or high calorie food does indeed produce substantial changes in their level of anxiety and their mood, a finding that appears to confirm our first hypothesis. Nevertheless, the second hypothesis is not verified.

The results of this study confirm the utility of virtual environments as instruments capable of provoking emotional reactions in patients with eating disorders, but they show too that it is necessary to introduce changes to improve the effectiveness of some of the developed situations. Particularly, the interaction with the application should be increased, especially with regard to the avatars representing human figures. In contrast to the food stimuli, which the subject can eat, in none of the environments was there any interaction between the subject and the other people present. This is probably why the presence or absence of other people has not produced significant changes in the levels of emotional reactivity.

CONCLUSION

Virtual reality seems to be a valid instrument particularly useful for simulating everyday situations that may provoke emotional reactions such as anxiety and depression, in patients with ED. Virtual environments in which subjects are obliged to ingest high-calorie food provoke the highest levels of state anxiety and depression. Nonetheless, certain changes need to be introduced in the environments in order to increase the impact that the presence of people has on the patients. These changes should aim principally to add movement and sound to the avatars representing human figures and increase the degree of interactivity between the users and the virtual environments.

REFERENCES

1. Carter F.A., Bulick C.M., Lawson R.H., Sullivan P.F. & Wilson J.S. (1996). Effect of mood and food cues on body image in women with bulimia and controls. *International journal of eating disorders,* **20 (1)**, 65-76.

2. Cash, T.F. & Deagle, E.A. (1997). The nature and extend of body image disturbances in anorexia nervosa and bulimia nervosa: a Meta-analysis. *International Journal of Eating Disorders,* **22**, 107-125.

3. Cash, T.F.; Cash, D.W. & Butters, J.W. (1983). "Mirror, mirror, on the wall...?": Contrast effects and self-evaluations of physical attractiveness. *Personality and Social Psychology Bulletin,* **9 (3)**, 351-358.

4. Gardner, D.M. (1998). Eating Disorders Inventory-2. Spanish adaptation: Corral, S., Gonzalez, M., Pereña, J. & Seisdedos, N. Barcelona: Ediciones TEA.

5. Gutiérrez, J. & Mora, M. (2000). *Cuestionario de Depresión Barcelona.* Not published manuscript. In B. Pérez, J. Gutiérrez-Maldonado & M. Ferrer-Garcia. *VII European Conference on Psychological Assessment.* Málaga (Spain), 1-4th April, 2004.

6. Haimovitz D.; Lansky L.M. & O'Reilly P. (1993). Fluctuations in body satisfaction across situations. *International Journal of Eating Disorders,* **3 (1)**, 77-84.

7. Heilbrun, A.B. & Flodin, A. (1989). Food cues and perceptual distortion of the female body: implications for food avoidance in the early dynamics of anorexia nervosa. *Journal of Clinical Psychology,* **45 (6)**, 843-851.

8. Hsu, L.K.G. & Sobkiewick, T.A. (1991).Body image disturbance: Time to abandon de concept for eating disorders? *International Journal of Eating Disorders,* **10 (1)**, 15-30.

9. Laberg, J.C.; Wilson G.T.; Eldredge K. & Nordby H. (1991). Effects of Mood on Heart Rate Reactivity in Bulimia Nervosa. *International Journal of Eating Disorders,* **10 (2)**, 169-178.

10. McKenzie, S.J.; Williamson, D.A. & Cubic, B.A. (1993). Stable and reactive body image disturbances in bulimia nervosa. *Behavior Therapy ,* **24**, 195-207.

11. Perpiña, C., Botella, C., & Baños, R. (2003). Virtual reality in Eating Disorders. *European Eating Disorders Review,* ***11* (3)**, *261-18.*

12. Perpiña, C.; Botella, C.; Baños, R.; Marco, J.H; Alcañiz, M. & Quero, S. (1999). Body Image and Virtual Reality in Eating Disorders: Is Exposure to Virtual Reality More Effective than the Classical Body Image Treatment? *CyberPsychology & Behavior,* **2(2)**, 149-155.

13. Riva, G. (1997). Virtual reality as assessment tool in Psychology. In G. Riva (Ed.), *Virtual Reality in Neuro-Psycho-Physiology.* Amsterdam: IOS Press.

14. Riva, G. (1998a). Virtual environment for body image modification: virtual reality system for treatment of body image disturbances. *Computer in Human Behavior,* **14 (3)**, 477-490.

15. Riva, G. (1998b). Virtual reality in psychological assessment: the Body Image Virtual Reality Scale. *CyberPsychology-and-Behavior,* **1(1)**, 37-44.

16. Riva, G. Bacchetta, M.; Baruffi, M.; Rinaldi, S. & Molinari, E. (1998). In G. Riva (Ed.), *Virtual Environments in Clinical Psychology and Neuroscience.* Amsterdam: IOS Press.

17. Saldaña, C.; Tomas, I. & Bach, L. (1997). Técnicas de intervención en los trastornos del comportamiento alimentario. *Estrés y Ansiedad,* **3 (2-3)**, 319-337.

18. Sepúlveda, A.R.; Botella, J. & León, J.K. (2001). La alteración de la imagen corporal en los trastornos de la alimentación: un metaanálisis. *Psicothema,* **13 (1)**, 7-16:

19. Skrzypek, S.; Wehmeier, P.M. & Remschmidt, H. (2001). Body image assessment using body size estimation in recent studies on anorexia nervosa. A brief review. *European Child & Adolescent Psychiatry,* **10**, 215-221.

20. Slade, P.D. & Brodie, D. (1994). Body Image distortion and eating disorder: A reconceptualitation based on recent literature. *Eating Disorders Review,* **1 (2)**, 32-46.

21. Smeets, M.A.M. (1997).The rise and fall of body size estimation research in anorexia nervosa: a review and reconceptualization. *European Eating Disorders,* **5**, 75-95.

22. Spielberger, C.D., Gorsuch, R.L. & Lushene, R.E. (1988). Spanish adaptation: Seisdedos, N. Barcelona: Ediciones TEA.

23. Thompson, A.M. & Chad, K.E. (2002). The relationship of social physique anxiety to risk for developing an eating disorder in young females. *Journal of Adolescent Health,* **31**, 183-189.

24. Thompson, J.K. (1996). *Body image, eating disorders and obesity.* Washington, DC: American Psychological Association.

Contact

Marta Ferrer-Garcia
Departamento de Personalidad
Evaluación y Tratamientos Psicológicos
Facultad de Psicología.
Paseo Valle de Hebron, 171
08035 Barcelona, Spain
Tel: +34933125126
Fax: +34934021362
E-mail: jgutierrezm@ub.edu
E-mail : martaferrerg@ub.edu

Investigation of Social Anxiety of Patients with Schizophrenia Using Virtual Avatar

H. J. Jang[1]B. A., J. Ku[3] Ph.D.,S. H. Park[1,2]M.S., S. Y. Kim[1] B. A., I. Y. Kim[3] M.D., Ph.D., C-H. Kim[1,2]M.D., Ph.D., J-J. Kim[1,2] M.D., Ph.D., S. I. Kim[3], Ph.D.

[1]Mind mapping laboratory, Institute of behavioral science in medicine, Yonsei University College of Medicine
[2]Department of Psychiatry, Yonsei University College of Medicine, Severance Mental Health Hospital, Gyunggi-do, Korea
[3]Dept. of Biomedical Engineering, Hanyang University, Seoul, Korea

Abstract: *Backgrounds: Patients with schizophrenia show a tendency to avoid social interaction because they feel great anxiety during their social interactions. As a result, they have trouble in making social relationships. This trouble is largely due to the fact that these patients show emotional withdrawal as well as passive/apathetic social withdrawal. Social deficits of these patients have been overcome through social skills training programs, which provide them opportunities to experience various social situations by role play method. Objectives: This study was conducted in order to investigate whether an interaction with a virtual avatar can evoke patient's social anxiety and the relationship between patient's symptom severity and social anxiety traits. Method/Tools: Fifteen patients with schizophrenia and fifteen controls were recruited. A male and a female avatar were generated. 2×2×3 (group, avatar's gender and avatar's emotional expression) was used in this experiment. Each avatar has three emotional expressions: are happy, neutral and angry. Subjects performed an introduction task in six conditions (gender × emotional expression) in random order. The task was composed of "approach", "listening to avatar's introduction" and "introduce oneself to the avatar". After all six tasks were performed, subjects completed a State-Trait Anxiety Inventory (STAI) questionnaire. In addition, patients' symptom severity was evaluated using the Positive and Negative Syndrome Scale (PANSS). Results: The social anxiety level to avatar's emotional representation was significantly different in the two group ($p<.001$). In the control group, the level was lowest when subjects coped with an avatar expressing "happy," while the highest anxiety level was shown when they faced an avatar expressing "angry." However, in the patient group, the level difference was not significant between "neutral" and "happy" avatar. Patients only showed a significantly high anxiety level when they experience the "angry" avatar condition compared to other two conditions. In a correlation analysis between patient's anxiety level and their symptom severity, social anxiety for "happy" and "neutral" avatars was positively correlated with the negative syndrome of PANSS (happy : $r=.539$, $p=.038$, neutral : $r=.533$, $p=.041$). Particularly, the anxiety level for "happy" and "neutral" avatars was positively correlated with two subscales (N1: blunted affect, N4: passive/apathetic social withdrawal) of the negative syndrome of PANSS (N1. happy: $r=.549$, $p=.034$/ neutral: $r=.536$, $p=.039$) (N4. happy: $r=.536$, $p=.039$/ neutral: $r=.658$, $p=.008$). Conclusion: Through this study, we discovered that virtual avatar displaying emotional expression can cause social anxiety in patients with schizophrenia and that a patient's symptom severity was correlated with social anxiety level. It could be said, from these results, that the more severe the negative symptoms a patient has, the greater social anxiety they will feel. This might be due to their passive, apathetic and isolated trait. They may tend to recognize socially positive emotion as fearful stimuli. This inference could be supported by the relationship between anxiety and subscales of negative symptom of PANSS. In this sense, we could say that a virtual avatar could provide an opportunity for patients to experience emotionally induced social situation. In addition, it could be used for training patients to cope effectively by experiencing emotions close to reality as well as to find out the clinical characteristics related to patient's symptoms.*

INTRODUCTION

Since it seriously affects higher mental functions, such as thinking, feeling, and perceiving,[1] schizophrenia can be considered one of the most devastating psychiatric disorders. The clinical course of schizophrenic patients is characterized by higher rates of relapse, disability and suicide when anxiety symptoms are concurrently experienced.[2,3] Although social anxiety symptoms are common in patients with schizophrenia,[4] they often goes unrecognized, or are considered to be part and parcel of the schizophrenic symptomatology.[5]

In fact, many patients with schizophrenia suffer from anxiety symptoms.[3] As a result, they actively avoid social interactions and appear to have little motivation to develop social relationships. Social interaction is often very anxiety provoking and leads to avoidance; patients often seek to escape from interactions initiated by others.[6] Existent research suggests that schizophrenic patients are particularly sensitive to conflict and criticism and will withdraw from potential conflict situations even when they are being taken advantage of or unjustly accused of things they have not done.[7]

In order to treat these patients with schizophrenia, effective psychological treatment studies for social anxiety have been developed and evaluated.[8,9] A combined program including exposure treatment together with cognitive therapy delivered in a group format has had significant outcomes.[10,11] Cognitive behavioral group treatment (CBGT) for social anxiety in schizophrenia was demonstrated to be effective as an adjunctive treatment[12] The important factors in the established therapeutic techniques are exposure to an anxiety evoking situation (gradual confrontation of feared event/situation) and to learning coping strategies for a situations through role-play (behavioral acting out). It is very important that patients experience social anxiety in treatment or in evaluation session. However, the existing therapeutic programs depend on patient's imagination ability.[12]

Therefore, virtual reality could be a powerful tool to provide patients with schizophrenia suffering from social anxiety to be immersed in a specific situation and feel and experienced social anxiety. Accordingly, the aims of this study were to develop a virtual avatar that could interact with patients with schizophrenia, and to evaluate whether a virtual avatar could evoke patient's social anxiety. In addition, this study was conducted in order to investigate the relationship between patient's symptom severity and social anxiety traits.

MATERIALS AND METHODS

Apparatus for this study

The apparatus for this study was composed of a personal computer, a 6 DOF (Degrees of Freedom) position sensor, an HMD (Head Mounted Display) and tracker. It could provide a user an immersive virtual environment. The position sensor was composed of a transmitter and receiver. The transmitter worked as an origin creating a surrounding magnetic around it, in order for the receiver to detect its position and orientation from the transmitter by calculating strength of the magnetic field. The receiver attached on the user's head could detect the user's head position and orientation so that the

	Schizophrenia	Normal
Age	28.69 ± 7.064	25.1 ± 1.553
Gender	M : 10 / F : 5	M : 9 / F : 6
PANSS Negative Syndrome Positive Syndrome General Psychopathology	 18.85 ± 3.23 19.78 ± 4.66 38.21 ± 5.80	

Table 1. Demographic data of participants

computer could render a virtual environment according to the user's head position and orientation.

Virtual Environment and Virtual avatars

Six avatars were designed for this study. They were divided into two categories, by emotion expression (happy, neutral, and angry) and gender (male and female). The arousal and valence level to the avatars' facial expression was matched through a previous study.

Clinical Experiment

Subjects

Fifteen patients with schizophrenia participated in this experiment. They were inpatients in the Severance Mental Hospital at Yonsei University. Fifteen normal control subjects were recruited for this study. The age (p=.222) and gender ratio (p=.891) of subjects were not significantly different between normal and patient group.

Experimental design

2 (group) ×2 (avatar's gender) ×3 (avatar's emotional expressions) mixed AVOVA experimental design was used for this experiment. Each subject experienced all 6 tasks in random order.

VR Task description

The task was composed of "approach," "listening to avatar's introduction," and "introduce oneself to the avatar" scenarios. A subject was instructed to walk up to an avatar until he or she felt comfortable to talk with the avatar. The subject was asked to say "hello" first. In response, the avatar's introduction was played. At the end of avatar's introduction, the avatar asked for subject's introduction. Then, the subject was to introduce him/herself to the avatar according to his feelings towards the avatar at that time.

Experimental Procedure

When a subject entered the experimental room, the subject completed a demographic information sheet and a consent form. Subsequently, s/he was given a brief introduction to the VR devices (HMD and tracker) and s/he was fitted into the equipment and positioned about 2.5 meter from an avatar. After the subject was positioned, the position sensor was calibrated so that all subjects could see the same direction in virtual environment before the experiment started. Then, a practice task was performed prior to the six main tasks. An avatar expressing "neutral" was provided as a practice session so that the subject could try to approach and look around. After all six main tasks were performed, the subject filled out the social anxiety questionnaire while seeing the same avatar again in order to recall his or her feelings during the task.

Measurements

* Social Anxiety Questionnaire

The social anxiety questionnaire data was acquired. It was initially developed by Spielberger et al.[17] and translated into Korean and validated[18] It is a self-report assessment device that is composed of questions reflecting state anxiety and trait anxiety. According to Spielberger, state anxiety reflects a "transitory emotional state or condition of the human organism that is characterized by subjective, consciously perceived feelings of tension and apprehension, and heightened autonomic nervous system activity." Therefore, state anxiety may fluctuate over time and can vary in intensity. In contrast, trait anxiety denotes "relatively stable individual differences in anxiety proneness." This study

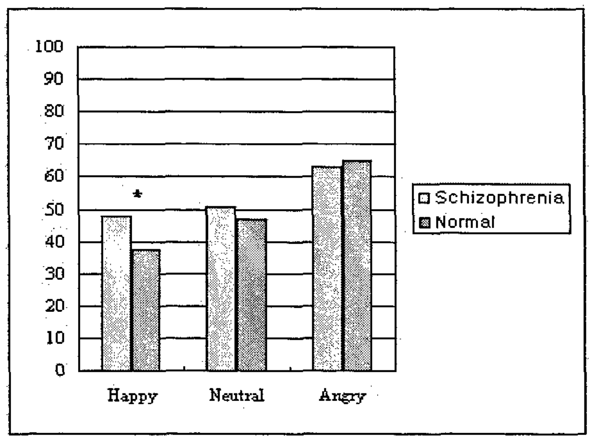


Figure 1. Comparison of social anxiety between patient group and normal group at each avatar's emotional representation. (* represents the significant difference at the 0.05 level)

excluded the measurement regarding the trait anxiety, because state anxiety would better represent social anxiety induced by experiencing of emotional virtual environment which was of interest in this study.

RESULTS

The main effect of the avatar's emotional expression was observed in both group (p<.001), while a main effect towards the avatar's gender was not observed.

An interaction effect between avatar's expressing emotion and the subject group was observed (p=.007). It means that social anxiety level to avatar's expressing emotion showed a significantly different pattern between the two groups. In the control group, the level was the lowest when they faced an avatar expressing "happy", and the highest when they met an avatar expressing "angry". However, members of the patient group did not show any anxiety level difference between "happy" and "neutral" avatar. In addition, they only showed a significantly higher social anxiety level when they experienced an avatar expressing "angry" compared to other emotional conditions.

In short, normal control subjects felt less social anxiety in happy and neutral condition than patients did (happy: p=.016/ neutral: p=.332), while normal subjects felt more social anxiety in angry emotion than patients did (angry: p=.490).

In order to learn how a patient's symptom severity affects their social anxiety level, a correlation analysis was performed between PANSS and their social anxiety level. As a result, the negative syndrome score of PANSS was positively correlated with social anxiety on "happy" and "neutral" avatars (happy: r=.539, p=.038, neutral: r=.533, p=.041).

In particular, a significant positive correlation was found between the social anxiety level evoked by "happy" and "neutral" avatars and two subscales (N1: blunted affect, N4: passive/ apathetic social withdrawal) of the negative syndrome of PANSS (N1. happy: r=.549, p=.034/ neutral: r=.536, p=.039 ; N4. happy: r=.536, p=.039/ neutral: r=.658, p=.008), but there were no correlations with other subscales, such as positive syndrome and general psychopathology score.

DISCUSSION

Schizophrenia is a multi-dimensional disorder and necessitates a comprehensive treatment approach.[13] Social anxiety symptom are described especially frequently by patients with schizophrenia in their clinical course.[14] Patients tend to avoid social interactions and appear to have little motivation to develop social relationships because social interaction often is very anxiety provoking.[6] This study explored whether an interaction with virtual avatar can provoke patient's social anxiety and investigated the relationship between patient' symptoms severity and social anxiety.

The observed result of a variation of anxiety level to a virtual avatar's emotional expression shows that an interaction with a virtual avatar can induce social anxiety of patients with schizophrenia. It means that a virtual reality or

	Positive syndrome	Negative syndrome	General Psychopathology
happy	-.020 (p=.944)	.539 (p=.038)*	.591 (p=,020)*
neutral	-.038 (p=.893)	.533 (p=.041)*	.474 (p=.074)
angry	-.323 (p=.240)	-.163 (p=.563)	.013 (p=.964)

Table 2. The correlations between the social anxiety level to avatar's emotional representation (happy, neutral, angry) and PANSS

( ) : p-value,
* : correlation is significant at the 0.05 level (2-tailed)

	Social anxiety level		
	happy	neutral	angry
N1. Blunted affect	.549*(p=.034)	.536*(p=.039)	.021(p=.942)
N2. Emotional withdrawal	.305(p=.269)	.194(p=.490)	-.304(p=.271)
N3. Poor rapport	.409(p=.130)	.374(p=.170)	-.335(p=.222)
N4. Passive/apathetic social withdrawal	.670**(p=.006)	.658**(p=.008)	-.054(p=.849)
N5. Difficulty in abstract thinking	.315(p=.253)	.318(p=.249)	-.155(p=.581)
N6. Lack of spontaneity & flow of conversation	.347(p=.206)	-.155(p=.581)	-.166(p=.554)
N7. Stereotyped thinking	.294(p=.287)	.320(p=.245)	.015(p=.958)

Table 3. The correlation between the social anxiety level to avatar's emotional representation and the subscales in negative symptoms of PANSS

( ) : p-value,
* : correlation is significant at the 0.05 level (2-tailed)
** : correlation is significant at the 0.01 level (2-tailed)

a virtual avatar can evoke social anxiety of patients with schizophrenia so that the characteristics of their social anxiety can be assessed or they can be trained in a socially stressful situation.

The positive correlation between the negative symptom score of PANSS and social anxiety level shows that the more severe negative symptoms a patients has, the higher the social anxiety that they experience. The negative symptoms include characteristics of avolition and anergia, a generalized lack of motivation, energy, and initiative; and anhedonia, an inability to experience pleasure and positive emotions. Therefore, the result can support the fact that the patients with schizophrenia avoid social interaction because the negative symptom mostly appear to reflect a diminution or loss of normal functions and this could amplify the anxiety in a social situation. However, there was no correlation between anxiety and the negative symptom severity in "anger" condition. It can be explained by an assumption that the avatar expressing "anger" evokes an anxiety too intense to be influenced by the negative symptoms.

The positive correlation between subscales of Negative symptom revealed in the further analysis can explain which characteristics in negative symptom influence patient's social anxiety. The results showed that blunted affect and passive/apathetic social withdrawal characteristics were correlated with the social anxiety. Therefore, patients with schizophrenia may feel anxious in social interactions because of their inability to perceive and respond properly to other's emotions.

CONCLUSION

Through this study, we found out that virtual emotionally expressive avatars can cause social anxiety to patients with schizophrenia and that patient's symptom severity was correlated with social anxiety during coping with avatar. From these results, it could be said that the severer negative symptoms the patient has, the higher social anxiety they feel. This might be due to their passive, apathetic and isolated trait. Therefore, they even tend to recognize socially positive emotion as fearful stimuli. This inference could be supported by the relationship between anxiety and subscales of negative symptom of PANSS. In this sense, we could say that a virtual avatar could provide an opportunity for patients to experience emotion induced social situation. In addition, it could be used for training them to cope effectively by experiencing emotions close to reality as well as to find out the clinical characteristics related to patient's symptoms.

REFERENCES

[1] Schults, S.K., Andreasen, N.C. (1999). *Schizophrenia,* Lancet, vol. 353, 1425-30.

[2] Hirsh, S.R., Jolley, A.G. (1989). *The dysphoric syndrome in schizophrenia and its implications for relapse.* British Journal of Psychiatry. Supplement 155, 46-50.

[3] Roy, 1. (1989). Suicidal behavior in schizophrenics. In: Williams, R., Dalby, J.T. (Eds.), *Depression in Schizophrenics.* Plenum, New York, NY.

[4] Cosoff SJ, Hafner J. (1998). *The prevalence of comorbid anxiety in schizophrenia,* Australian and New Zealand Journal of Psychiatry, 33: 67-72.

[5] Walker EF. (1994) *Developmentally moderate expressions of the neuropathology underlying schizophrenia.* Schizophrenia Bulletin, 20: 453-480.

[6] Bellack, A.S, Mueser, K.T., Gingerich, S., and Agresta, J. (1997). *Social Skills Training for Schizophrenia: A Step-by-Step Guide.* New York: The Guilford press, 3-9.

[7] Bellack, A.S, Mueser, K.T., Wade, J., Sayers, S.L., and Morrison, R.L. (1992). *The ability of schizophrenics to perceive and cope with negative affect.* British Journal of Psychiatry, vol. 160, 473-480.

[8] Gould, R.A., Buckminster, S., Pollack, M.H., Otto, M. W., Yap, L. (1997). *Cognitive-behavioral and pharmacological treatment for social phobia*: a meta-analysis. Clinical Psychology-Science and Practice 5, 291-306.

[9] Van Dyck, R (1996). *Non-drug treatment for social phobia.* International Clinical Psychopharmacology 11, 65-70.

[10] Mattick, R.P., Peter, L., Clarke, J. C., (1989). *Exposure and cognitive restructuring for social phobia; a controlled study.* Behavior Therapy 20, 3-23.

[11] Hope, D.A., Heimberg, R.G., Brunch, M.A.. (1995). *Dismantling cognitive behavioral group therapy for social phobia.* Behavior research and Therapy 33, 637-650.

[12] Patrick Kingsep, Paula Nathan, David Castle. (2003).*Cognitive behavioral group treatment for social anxiety in schizophrenia.* Schizophrenia Research 63, 121-129.

[13] Andreasen, N.C. (1995). *Symptoms, signs, and diagnosis of schizophrenia.* The Lancet 346, 477-481.

[14] Siris, S.G., (2000). *Depression in schizophrenia: perspective in the era of atypical antipsychotic agents.* American Journal of Psychiatry. 157, 1379-1389.

[15] Andreasen, N.C. (1982). N*egative symptoms in schizophrenia: Definition and reliability.* Archives of General Psychiatry, 39, 784-788.

[16] Bellack, A.S., Blanchard, J.J., & Mueser, K.T. (1996). *Cue availability and affect perception in schizophrenia.* Schizophrenia Bulletin, 22, 535-544.

[17] Spileberger, C. D., Gorsuch, R.L., & Lushene, R.E. (1970). *Manual for the State-Trait Anxiety Inventory.* Pal. Alto, CA: Consulting Psychologist Press.

[18] Kim, J. T. (1978). *The relationship of trait anxiety and sociality,* M.A. Thesis of Korea University.

Contact

Hee Jeong Jang
Mind Mapping Laboratory
Institute of Behavioral Science in Medicine
Yonsei University College of Medicine
Email: saccylia@hanmail.net

Investigation of Social Cue Perception in Schizophrenia using Virtual Reality

K. Kim, M.S.[1], J-J. Kim, M.D., Ph.D[2], J. Kim, M.S.[1], D-E. Park, B.S.[1], J. Ku, Ph.D.[1], H. J. Jang, B.A.[2], S. H. Park, M.D.[2], S. Y. Kim, B.A.[2], C. H. Kim, M.D., Ph.D[2], J. H. Lee, Ph.D.[1], I. Y. Kim, M.D., Ph.D.[1], and S. I. Kim, Ph.D[1]

[1]Department of Biomedical Engineering, Hanyang University, Seoul, Korea;
[2]Institute of Behavioral Science in Medicine, Yonsei University Severance Mental Health Hospital, Seoul, Korea

Abstract: Background/Problem: *An impairment in social skills is one of the few criteria that all individuals diagnosed with schizophrenia must meet Successful social skills require the coordination of many abilities, including social perception, which involves the decoding and interpretation of social cues from others. Previous studies on social perception in schizophrenia have focused on interpreting the emotions from facial expressions. There are some reports showing the potential of virtual reality (VR) in social skills training. This study developed VR for assessing the social perception including an interpretation of non-facial expressions. In addition, the suitability of VR for determining a schizophrenia patient's social perception ability was evaluated.*

Method/Tools: *For an effective social perception test, VR consisting various situations and contents may be needed. Therefore, the VR Behavior & Facial Data Base architecture (VRBFDB) was used for the easy and fast VR composition. The contents can be divided into two areas "interpretation of the relevant cue test" and "Emotion Recognition test." The "Interpretation of the relevant cue test" is composed of the recognition of a non-verbal social situation as well as the recognition of a verbal social situation, and the "Emotion Recognition test" is composed of happy, sad, angry and surprise facial expression recognition.*

There were 17 subjects (12 males and 5 females) and 17 controls (12 males and 5 females). This study obtained the data from the VR, a questionnaire, and the subject's symptoms. The VR data included the participant's response results, reaction time, presence and computer experience . The questionnaire data included age, education, gender, intelligence (K-WAIS) etc. The symptom data was measured using the PANSS (Positive and Negative Syndrome Scales).

Results/Conclusion: *According to the results, schizophrenia subjects perform significantly worse on the VR test than normal subjects, and some parameters the correlated with previous clinical test.*

INTRODUCTION

"Social skills" are interpersonal behaviors that are normative and/or socially sanctioned. They include items such as dress and behavior codes, rules about what to say and what not to say, and stylistic guidelines about the expression of affect, social reinforcement, interpersonal distance etc [1]. Impairment in social skills is one of the criteria that all individuals diagnosed with schizophrenia must meet [2]. These deficits make it difficult for many clients to establish and maintain social relationships, fulfill social roles or to have their needs met [1].

Successful social competence is based on a distinct set of component skills [3]. These components can be roughly divided into two broad sets: expressive skills (speech content, paralinguistic features, and nonverbal behavior) and social perception skills (interpretation of the relevant cues, emotion recognition). However, regardless of the individual's ability to emit socially skillful responses, he or she cannot be effective without an accurate social perception that involves the decoding and interpretation of various social cues in others [1]. Previous research on social perception in schizophrenia

focused on the interpretation of emotion from the facial expressions. Although facial expression is admittedly an important social cue, the restrictive focus on the interpretation of this single nonverbal cue was too narrow given the breadth of the social deficits in schizophrenia [4].

There are many social cue elements that substantially contribute to socially skillful behavior. And social cue perception is the most fundamental requirements for accurate social perception [1]. These social cues can be divided into verbal or nonverbal social signals [4]. Many chronic clients exhibit poor interpersonal behavior precisely because their focus of attention is primarily internal, and is only intermittently and selectively directed outward. Another aspect of social perception involves the accurate perception of emotion. Emotion is frequently communicated by a subtle combination of verbal and nonverbal cues. Given that the emotion states of an interpersonal partner are critical factors in determining the appropriate response, a socially skilled individual must be able to 'read' the emotional cues. Such personal perception and analysis enhances accurate communication and is essential for the effective resolution of conflict and distress [1].

The existing social perception and social skill training method rely upon role-play, either acted out or observed through the use media and materials [5, 6]. Typically, it involves the use of a puppet or videotape [7]. However, despite the success of some social skills training programs in enhancing skill acquisition within a training setting, it has limitations in the transfer of training and the generalization of skills to the natural environment [8]. Moreover, it does not focus on social perception, which is a basic and primitive aspect of social skills.

Recently, there have been some reports on the potential of virtual reality (VR) in social skills training [7, 9, 10]. Virtual environments (VE) allow the users to interact with a three-dimensional computer-based world incorporating impressive graphics and design. The users can move through a VE in real time using a joystick or mouse. They can interact with the objects in a scene and are typically represented as a humanoid "avatar" [9]. The cardinal feature of VR is the provision of a sense of actual presence in the stimulated environment [11, 12]. In addition, complete control over the content is possible, and the performance data can be stored in a database. VR provides patients with added motivation by adding gaming factors in a

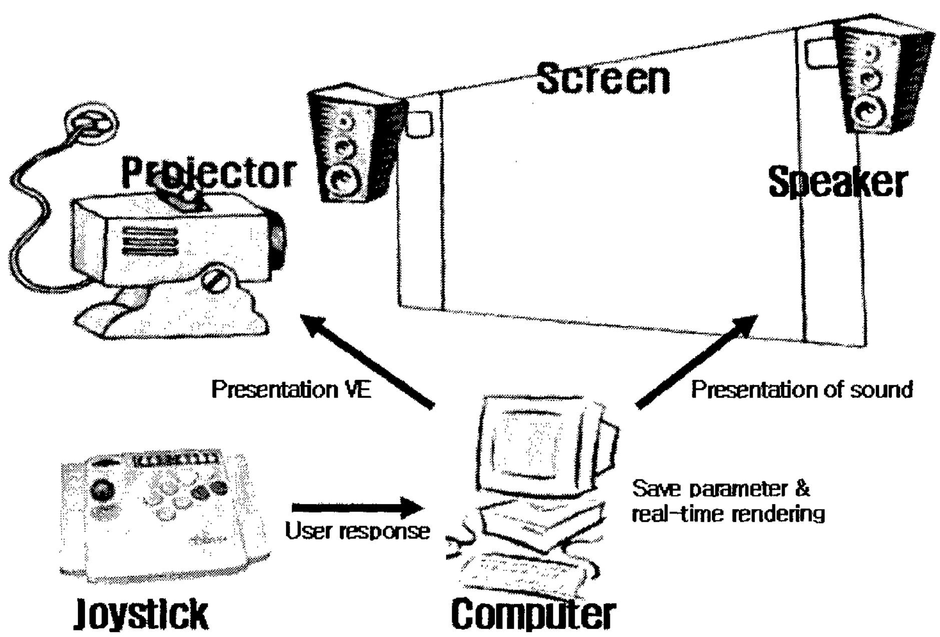


Figure 1. Hardware for virtual reality

safe virtual environment that eliminates the risks caused by errors [13].

This study developed a VR Behavior & Facial Data Base architecture (VRBFDB) for an easy and fast VR composition. The VTBFDB was used to design VR social perception contents including the interpretation of verbal cue perception, non-verbal cue perception, and the recognition of emotion. It was hypothesized that schizophrenia subjects would perform significantly worse on the VR test than normal subjects.

MATERIALS AND METHODS

System

The VR system consisted of a Pentium IV PC, DirectX 3D Accelerator VGA Card, Projection Screen, and Joystick (Dahoon DHU-1500), which could be used as an easy response to allow the patients to perform the virtual reality scenario comfortably. The PC, which is fitted with a 3D Accelerator VGA Card, generates real-time virtual images for the subject. Figure 1 shows the hardware for the VR.

VRDFDB

A VR software framework, called a VR Behavior and Facial Data Base (VRBFRDB) was set up to provide a variety of VR scenarios. The VRBFDB is composed of an avatar database (14 avatars) as well as a motion and facial expression database. The motion and facial DB includes 93 behaviors and 7 facial expressions. 14 avatars designed by the 3D Max Studio could be used in different situations by applying a different texture map, which affects the avatar's clothes, hair style, and skin color. Seven facial expressions were implemented using a morphing technology. Primitive facial expressions (happy, sad, angry, smile, surprising, embarrassing, and bored) were controlled by the parameters to express complicated and subtle facial expression. Ninety-three behaviors are made by a biped, which is used to represent the avatar's action. Each behavior could be attached to any avatar, which was already made, and the avatar's animation, which was matched with each scenario, could be made. According to the VR scenario, the avatars, behaviors, and facial expressions, which are needed in the scenario, were integrated and then exported in .Med files. The necessary environment in the scenario was exported to a .Map file, which was used in the A6 Game Studio Engine. The exported avatar, which included the behaviors and facial expression, was merged with the .Map file and rendering by an A6 Game Studio rendering engine. Figure 2 shows the VRBFDB architecture.

Virtual environment and task

VR is designed to assess the social perception. During the experiment, the subjects perform VR and he/she chooses whether it is suitable or unsuitable (Likert type scale: 5 point). The VR is

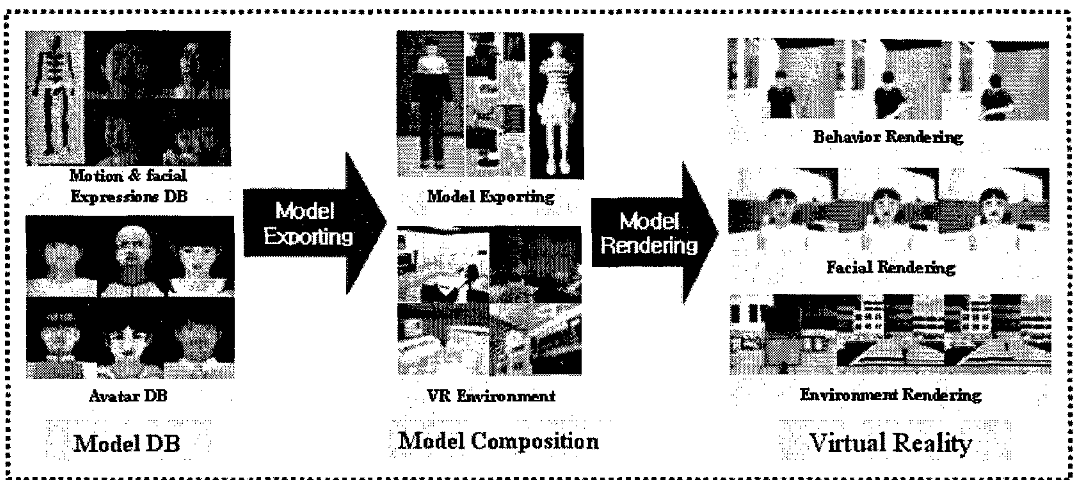


Figure 2. VR Behavior & Facial Data Base Architecture (VRBFDB)

Interpretation of relevant cue	Nonverbal social cue (8) - Recognize avatar's physical gesture - Recognize traffic signal - Unusual street situation - Suitable/Unsuitable behavior according to situation
	Verbal social cue (6) - Polite/rude dialog - Suitable/Unsuitable greeting
Emotional Recognition	Happy situation (6) - Recognize happy facial expression - Recognize happy situation
	Sad situation (4) - Recognize sad facial expression - Recognize sad situation
	Angry situation (6) - Recognize angry facial expression - Recognize angry situation

Table 1. The contents of the VR social perception tool.

composed of an 'Interpretation of Relevant Cue (IRC)' and 'Emotional Recognition (ER)'. Table 1 shows the contents of the VR. The IRC is composed nonverbal and verbal social cues. The ER is composed a happy situation, a sad situation and an angry situation. In the nonverbal social cue perception, the physical gesture and social situation was selected because they can be used as virtual 'avatar' and virtual 'context'. In addition, the VR contents for verbal social cue were composed of a basic verbal component (for example suitable or unsuitable greeting and polite or rude expression). In the emotion recognition, happy, sad, angry emotion recognition contents were designed. During the emotional recognition contents, the patients must recognize the emotion considering the avatar's facial expression and context.

EXPERIMENT (SUBJECTS, PROCEDURES, MEASUREMENT)

Subjects.

The subjects consisted of 17 inpatients (12 males and 5 females) diagnosed with schizophrenia, and 17 control subjects (12 males and 5 females) (Table 2). The patients' mean total PANSS (Positive and Negative Syndrome Scale) was 77.12 (SD 8.43), the positive and negative PANSS means were 18.00 (SD 2.83) and 20.18 (SD 3.26) respectively.

There were no significant differences between the patient and control groups. The score on the patient's computer using the experience was checked as (1) very strange, (2) strange, (3) common, (4) experienced, and (5) very experienced.

	Patient group (n=17)	Control group (n=17)
Age (years)	30.41 ± 5.36	30.05 ± 6.07
Sex (M:F)	12 : 5	12 : 5
Computer-using experience	3.41 ± 1.23	3.82 ± 1.13

Table 2. Subject

	Patient group (Schizophrenia)	Control group (Normal)
Interpretation of relevant cue	3.49 ± 0.75**	4.20 ± 0.40
Emotional Recognition	3.32 ± 0.35**	3.92 ± 0.32
Nonverbal social cue	3.44 ± 0.97**	4.24 ± 0.42
Verbal social cue	3.54 ± 0.63**	4.17 ± 0.54
Happy situation	3.49 ± 0.59**	4.38 ± 0.29
Sad situation	3.34 ± 0.62**	3.93 ± 0.57
Angry situation	3.13 ± 0.31*	3.47 ± 0.49

* p<0.05, **p<0.01 between patients group and control group

Table 3. Results of the Parameters from the virtual Environment

Procedure.

Prior to the experiment, the subjects were asked to complete the form containing the patient's name, age, education and computer experience, and were examined using the psychological tests (ITQ, K-WAIS). In addition to this test, the patients were examined using the Positive and Negative Syndrome Scale (PANSS). During the experiments, the subjects first read the instruments and completed a pretest to use the joystick. In the VR tasks, the subjects observed randomized VR contents and response according to their feelings. After the VR tasks, the subjects were asked to complete the form PQ (Presence Questionnaire) and VRQ (Virtual Reality Questionnaire). The form contains estimations about their presence, experimental environment and virtual reality.

Measurements.

This system measured various parameters while the subject experienced the VR system. As shown Table 3, the interpretation of the relevant cue, the emotion recognition, the nonverbal social cue, the verbal social cue, the happy situation, the sad situation, and the angry situation were measured. The interpretation of the relevant cue and emotion recognition were calculated according to their subcomponent in table 1.

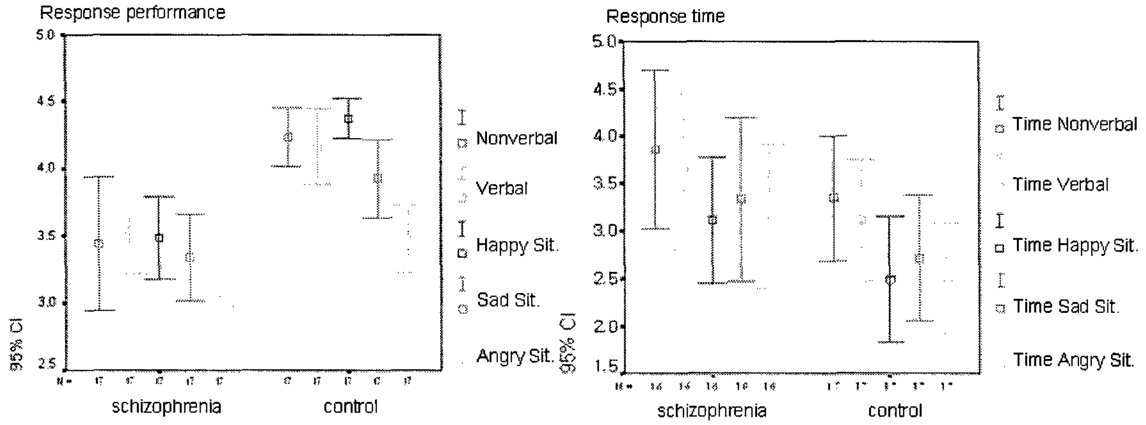


Figure 3. The mean comparison between the patient and normal group. (a) VR response comparison. (b) VR response time comparison.

RESULTS

According to Table 3, the VR parameter in the patient and control groups was significantly different ($p<0.05$ or $p<0.01$). In addition, there was no significant deference between the groups (patient and control group; see Table 1). The seven parameters in Table 3 show a significant difference between the patient and normal groups when using this program as an assessment tool.

The results given in Figure 3 show a mean comparison between the patient and normal groups. Figure 3a shows that the schizophrenia group's social perception ability was significantly poorer than the normal group. In particular, the schizophrenia group's nonverbal social cue perception ability was poorer than the verbal social cue perception ability. In the normal group, the nonverbal social cue perception ability was greater than the verbal social cue perception ability. Figure 3b shows the response time of the schizophrenia patient occurred later than that of the normal group. However, there was no statistically significant difference and no tendency difference.

In order to assess the relationship between the social perception ability and symptoms, the Spearman's correlation between the performance on VR and PANSS was computed. There is no significant difference between the social perception component and the PANSS total scores (positive, negative and general score). The result shown in Table 4 shows a correlation between the social perception component and the PANSS individual scores. However, more conservative criteria are needed when interpreting the correlation in the PANSS individual score. As the correlation was significant at the .01 level, the verbal cue perception (Auditory) showed a negative correlation with delusions, the recognition of a happy facial expression had a negative correlation with conceptual disorganization, and the recognition of an angry facial expression had a negative correlation with stereotyped thinking.

DISCUSSION

VR was developed using the VRDFDB for a fast and easy composition. This study examined the social perception between a schizophrenia group and a normal group using the developed VR.

There are many advantages in VRDFDB. First, it can be fast developing. The user only selects the behavior and facial expression according to a suitable sequence in a predefined Data Base. The fast development may be an essential component in a VR Social perception tool because social perception requires various situations. Second, VRDFDB can be easily modified. Previous VR systems were difficult to modify

	PANSS (Positive and Negative Syndrome Scale)			
	Delusions	Conceptual Disorganization	Suspiciousness /Persecution	Stereotyped thinking
Behavior Cue perception	.107 .684	-.010 .968	.504* .039	-.028 .914
Verbal Cue perception (Auditory)	-.659** .004	-.497* .042	.113 .665	-.166 .525
Recognize happy facial	-.388 .124	-.638** .006	.253 .327	-.435 .081
Recognize sad facial	-.008 .976	-.574* .016	.092 .727	-.400 .111
Recognize angry facial	-.293 .254	-.602* .011	.021 .935	-.634** .006

*. Correlation is significant at the .05 level
**. Correlation is significant at the .01 level

Table 4. Correlation analysis with PANSS

during the developing period. However, VRDFDB can be modified easy by simply selecting another behavior and a facial change parameter. On the other hand, VRDFDB has some problem. First, it has limited behaviors and facial expressions. In a one time DB composition, there are 14 avatars with 93 behaviors and 7 types of facial expressions. Despite this, there is still a large number. However, more avatars and behaviors are needed for sufficient social perception content. Second, it is still a programmer level architecture. Indeed, only programmer can develop VR using our architecture. Ideally, everyone including clinicians could make VR, but in view of current VR research this is impossible until now.

The results of the VR social perception tasks require more research in clinical aspect. However, some results are statistically significant or concur with previous reports. First, according to the result shown in figure 3 and table 3, the social perception abilities in schizophrenia and normal groups were significant different. This result confirms the previous research using VR that the schizophrenia patient's social perception ability is worse than normal subjects [14]. Second, contrary to the tendency of a normal performance task between nonverbal and verbal social perception, there was a reverse tendency within the schizophrenia patient group, which partially correlated with Toomey's research [15]. Third, although a correlation between Positive and Negative Syndrome Scale (PANSS) and virtual reality parameters was found, more research will be needed to confirm the clinical significance.

This paper used VRDFDB for the fast and easy construction of a virtual environment, and tested the possibility of a social perception system using VR. Although a more profound discussion about the virtual reality parameters will be needed to explain the clinical result, a VR system can be used to assess a schizophrenia patient's social cue perception ability by comparing the performance between a normal and schizophrenia group in a given virtual reality task. In future, VR will be used to train and assess the social problem solving ability or social skills on the whole.

REFERENCE

1. Alan S. Bellack, Kim T. Mueser, Susan Gingerich, & Jule Agresta (1997). *Social Skill Training for Schizophrenia.* New York: The Guilford Press.

2. American Psychiatric Association (1994). *Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). 4^{th} ed.*. Washington DC. American Psychiatric Association.

3. Morrison R. L. (1990). Interpersonal dysfunction. In A. S. Bellack, M. Hersen, & A. E. Kazdin (Eds.), *International handbook of behavior modification and therapy (3rd ed., pp. 503-522).* New York: Plenum Press

4. Rosemary Toomey, David Schuldberg, Patrick Corrigan & Michael F. Green (2002). Nonverbal social perception and symptomatology in schizophrenia. *Schizophrenia Research.* 53:83-91.

5. Cartlege. G., & Milburn J.A. (1978). The case for teaching social skills in the classroom: A review. *Review of Education Research.* 1:133-155.

6. Michelson L., & Wood R. (1980). *Behavioral assessment and training of children' social skills. Progress in Behavior Modification.* New York: Academic Press.

7. Howard S. Muscott & Timothy Gifford (1994). Virtual Reality Applications for Teaching Social Skills to Students with Emotional and Behavioral Disorders. 1994 VR Conference Proceedings.

8. Goldstein A.P. (1998). PREPARE: A prosocial curriculum for aggressive youth. In H.S. Muscott (Ed.), Prosocial skills training for children with emotional disturbances (ED) and behavioral disorders (BD): The journey of 1,000 miles begins with the first few steps (Special issue). *Perception*, 24(1): 20-25.

9. S. Parsons & P. Mitchell (2002). The potential of virtual reality in social skills training for people with autistic spectrum disorders. Journal of Intellectual *Disability Research*, 46:430-443.

10. A. Leonard, P. Mitchell & S. Parsons (2002). Finding a place to sit: a preliminary investigation into the effectiveness of virtual environments for social skills training for people with autistic spectrum disorders, *International Conference Disability Virtual Reality & Associated Technique*. 249-258.

11. Witmer BG, Singer MJ. (1998). Measuring presence in virtual environment: a presence

questionnaire. *Presence.* 7:225-40
12. Kwanguk Kim, Jaehun Kim, Jeonghun Ku, Deongyoung Kim, Won Hyek Chang, Dong Ik Shin, Jang Han Lee, In Young Kim & Sun I. Kim (2004). A virtual reality assessment and training system for unilateral neglect. *CyberPsychology & Behavior* 7:742-749.
13. Jang Han Lee, Jounghun Ku, Wongeun Cho, Wonyoung Hahn, In Y. Kim, Sang-min Lee, Younjoo Kang, Deog Young Kim, Taewon Yu, Breda K. Wiederhold, Bark D. Wiederhold, & Sun I. Kim (2003). A virtual reality system for the assessment and rehabilitation of the activities of daily living. *CyberPsychology & Behavior.* 6:383-388.
14. David L. Penn, Mark Ritchie, Jennifer Francis, Dannis Combs & James Martin (2002). Social perception in schizophrenia: the role of context. *Psychiatry Research.* 109: 149-159.
15. Rosemary Toomey, Larry J. Seidman, Michael J. Lyones, Stephen V. Faraone, & Ming T. Tsuang (1999). Poor perception of nonverbal social-emotional cues in relatives of schizophrenia patients. Schizophrenia Research 40: 121-130.

Contact

Kwanguk Kim
1Department of Biomedical Engineering
Hanyang University
Seoul, 133-605, Korea
Phone: +82-2-2290-0693
Fax: +82-2-2296-5943
Email: kwang6@bme.hanyang.ac.kr

Relationship between Social Response to Virtual Avatar and Symptom Severity of Patients with Schizophrenia

[1]J. Ku, Ph.D., [2]J. J. Kim, M.D., Ph.D., [2]H. J. Jang, B. A., [2]S. H. Park, M.D., [2]S. Y. Kim, B.A., [2]C-H. Kim, M.D., Ph.D., [1]K. U. Kim, M.S., [1]Ja. H. Kim, M.S., [1]J. H. Lee, Ph.D., [1]I. Y. Kim, M.D., Ph.D. and [1]S. I. Kim, Ph.D.

[1]Dept. of Biomedical Engineering, Hanyang University, Seoul, Korea
[2]Department of Psychiatry, College of Medicine, Yonsei University, Severance Mental Health Hospital, Gyunggi-do, Korea

Abstracts: *A virtual avatar has been used for various applications that require communication among persons, or to train or educate people by demonstrating human-like behavior. Recently, much research has shown an enhancement of virtual avatar technology, with the avatar perceived as a real person. As a result, the technology could begin to be used for observing human behavior to a virtual avatar. This paper concerns whether a virtual avatar could acquire patients' behavioral characteristics during experiencing a virtual task which is composed of approaching and conducting a short conversation. For this, we designed a virtual avatar that was standing in a virtual room, with eleven schizophrenic patients assigned the task of approaching the virtual avatar, initiating a conversation, and providing answers to the avatar's questions. To measure behavioral parameters in the virtual environment, we acquired the interpersonal distance and the verbal response time. In addition, we rated patients on the Positive and Negative Syndrome Scale (PANSS) in order to investigate a relationship between patients' symptomatic characteristic and behavioral parameters. Results of this study revealed that the interpersonal distance was negatively correlated with the negative syndrome scale, which is a subscale of PANSS ($r=-0.687$, $p=0.02$). By contrast, the verbal response time was not correlated with any other subscale of PANSS. However, after analyzing this variable with sub-items of the negative syndrome of PANSS, two positive correlations were found: one with blunted affect ($r=.638$, $p=.035$) and the other with poor rapport ($r=.615$, $p=.044$). The negative correlation between the distance and negative symptom severity observed in this study is consistent with studies that investigated the relationship between schizophrenic patients' interpersonal distance and their symptoms. The positive correlation between the verbal response time acquired and subscales in PANSS in this study could be explained by the definition of these subscales. Therefore, this positive correlation means that the less a patient's emotional response, intimacy, and relationship making with a virtual avatar, the slower they answer the avatar's question. Inferring from these results, we conclude that the virtual avatar could be perceived as a real human by schizophrenic patients, the avatar could facilitate the schizophrenic patients' behavioral characteristics, and the avatar could be used as a tool for assessing the behavioral characteristics of patients with schizophrenia.*

INTRODUCTION

Virtual Reality (VR) has the potential to provide a realistic three-dimensional world generated by computer graphics, with which the user can interact, so that he or she can navigate within and manage the virtual world and obtain computerized objective scores. Due to its capacity to provide realistic three-dimensional environments to users, VR has already been applied to many fields such as industry, the military, entertainment and medicine. In particular, many medical applications have emerged because of its ability to provide a realistic, interactive, immersive, and safe environment; this complements the fact that it provides a flexible and controlled experimental and therapeutic environment. It has been applied to several types of mental disorders such as illness,[1-3] and attention deficit disorders (ADD)[1,4] for assessing patients' cognitive functions[5] and for providing training for stroke patients' activities of daily living (ADL).[6] VR has also been used to assess and investigate human characteristics in three-dimensional envi-

ronments such as for navigation,[7] and spatial memory.[8]

Moreover, recent technological advances in avatars enable computer-generated entities to mimic both the appearance and behaviors of humans. Thus, Virtual Environments (VEs) can be more realistic and social, because VEs can be populated by representations of people as well as objects. Recent improvements in graphic and animation technology have made it possible for the avatars used in these visual images to appear increasingly human-like. Studies have shown that people report feeling some level of presence in almost all mediated environments and even respond socially to computer-generated human-like entities.[9]

In addition to these results, several studies have shown that human behavioral characteristics, such as proximity and social influence could be investigated using a virtual avatar or a social situation populated with several avatars.[10,11] These studies support the hypothesis that a VE populated with avatars could influence human behavior and emotion.

From these studies showing the capacity and potential of VR, we can predict that VR could also be useful for investigating the interpersonal behavior of patients with mental illness. In particular, we are interested in applications to schizophrenia because it is one of the most devastating psychiatric disorders, as it seriously affects the higher mental functions, such as thinking, feeling and perceiving.[12] The Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV), states that schizophrenia involves problems in one or more major areas of functioning (e.g., interpersonal relations, work or self-care).[13] It is also characterized by symptoms such as hallucinations or disorganized thinking, the loss of goal-directed behaviors, and deterioration in social role functioning. Due to these deficits, patients with schizophrenia have a negative effect on their partners in interpersonal or social interaction and they suffer when living with others. Although investigating the interpersonal behavioral characteristics of patients with schizophrenia is necessary to understand and treat them, currently only subjective materials such as videotaping or clinical observation are available for assessing patients' interpersonal behavior characteristics during an interaction. The problems of those methods for assessing the patient's behavior concern the difficulty in establishing a controlled experimental situation and observing behavior consistently.

Due to these needs, in this study, we aimed to develop a method for assessing the interpersonal behavioral characteristics of patients with schizophrenia using VR technology. VR technology has many advantages in providing a realistic environment, and allows us to investigate how schizophrenic patients perceive and react to a virtual avatar. It also allows an investigation of whether interpersonal behavior toward a virtual avatar is similar to behavior in response to a human.

For accomplishing the goal of this study, a virtual room, in which a virtual avatar is standing, was designed and a short conversation task was assigned to the patients. And, as objective parameters from patients' virtual experience, the interpersonal distance and the verbal response time were chosen because they are representative factors to represent a relationship between people and play an important role in conversation as well as social life.[14] And, PANSS of the patients were also acquired in order to investigate the relationship between their symptom and the behavioral parameters. Through the investigation of the relationships among these parameters, we expected that the patients react to the virtual avatar in the same way as to human and the virtual environment and the virtual avatar could be a tool for assessing the interpersonal behavior characteristics of the patients with schizophrenia.

MATERIALS AND METHOD

Subjects

We recruited 11 patients, 5 male and 6 female, diagnosed with schizophrenia, for this experiment. They were inpatients at the Severance Mental Health Hospital in Korea and were able to perform a task and to control an interface such as a joystick. Their mean age was 29.54 ± 8.95 years (mean ± SD) and their PANSS score were 21.81 ± 4.62 (mean ± SD) for negative symptoms, 19.45 ±3.67 (mean ± SD) for posi-

tive symptoms and 40.91 ±5.54 (mean ± SD) for the general psychopathology score.

Apparatus

The apparatus for this experiment was composed of a personal computer (PC), a large screen, a beam projector, and a joystick, which were used by the subjects to experience a VE. The VE consisted of a room and a male-shaped virtual avatar that had eye blink and breathing motions, but no facial expressions and no gestures. The VE and avatar were rendered on a PC using "3D Game Studio" (Conitec Datasystems Corporation), which is a commercial 3D game engine, and projected onto a big screen through a beam projector. This method was chosen because a patient with schizophrenia may feel discomfort when wearing a head mounted display (HMD) and tracker. The subjects moved forward and backward by pushing or pulling the lever on the joystick, and initiated conversation by pressing the talk button on the joystick.

Task Description

We designed the task so that the participant had to initiate and conduct a short conversation with a virtual avatar. Therefore, a subject had to approach a virtual avatar standing in front of the subject by pushing the lever of the joystick forward and try to talk to the virtual avatar by pressing the talk button on the joystick. In order to initiate the conversation, subject had to press the "talk" button then say "hello". After initiation, the avatar and the subject exchanged questions and answers. In order to do this, we generated a fixed simple scenario for a short conversation and the clinician controlled the scenario according to the subject's verbal response (for a detailed script, see Fig. 2).

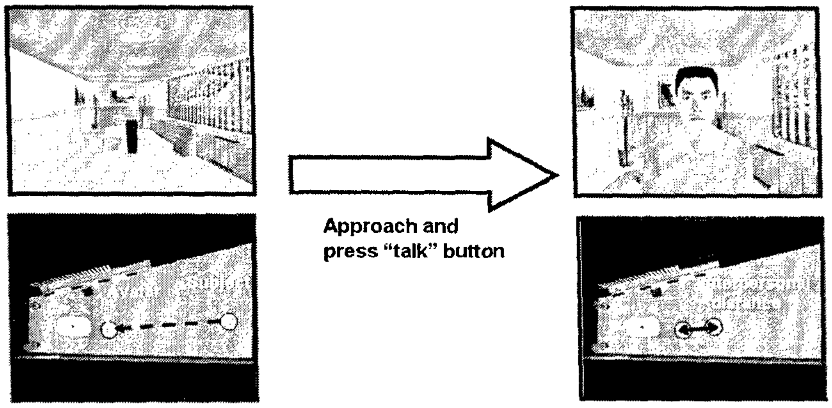
Measurements

For VR-based measurements, we required the interpersonal distance and the verbal response time and saved them during the task. We defined former as a virtual distance between a subject and the avatar at the moment that the subject approached and pressed the "talk" button to initiate a conversation. It is reasonable for the distance to be regarded as the interpersonal distance, since the distance means the comfortable distance for having a conversation with the virtual avatar. We defined the verbal response time as the time elapsed following the moment that the avatar asked the subject a question until the point that the subject commenced the answer.

The PANSS, used to measure the severity of the patients' positive and negative symptoms, allowed assessment of the relationship between symptoms and behavioral characteristics. It is composed of three subscales: the negative syndrome scale, positive syndrome scale, and general psychopathology scale. In more detail, each subscale is determined by assessing several representative schizophrenic symptoms.

(a) (b)

Figure 1. Scene of an experiment (a) and a virtual avatar standing in a virtual room (b). A subject is sitting on a chair, a screen is located in front of the subject and the subject controls a joystick to move and respond.



Script for a short conversation

Subject : Hello ?
Avatar : Hello. Nice to meet you. What is your name?
Subject : My name is XXX. What is your name?
Avatar : My name is OOO. How old are you?
Subject : I'm 28 years old. How about you?
Avatar : I'm 29 years old.

The verbal response time

Figure 2. Diagrammatic representation of the task and parameters, and a script for a short conversation for this task.

For example, the negative syndrome scale has seven characteristics of schizophrenia, which are blunted affect, emotional withdrawal, poor rapport, passive apathetic social withdrawal, difficulty in abstract thinking, lack of spontaneity & flow of conversation and stereotyped thinking.[15]

RESULTS

The mean and standard deviation of the interpersonal distance was 104.86 (SD=60.39) in virtual unit, which did not convert to a real unit, because only the relative difference among patients was of interest. And, when we investigated the relationship between the distance and PANSS subscales, the distance was significantly negatively correlated with the negative syndrome score, which is one of the PANSS subscales (n=11, r=–0.687, p=0.02), but we saw no correlations with other subscales, such as positive syndrome and general psychopathology score.

The mean and standard deviation of the verbal response time was 4.64 seconds (SD=1.40). And, when we investigated the correlation between the verbal response time and PANSS scores and its subscales, there was no significant correlation with positive and negative symptoms and the general psychopathology score.

However, there were two significant correlations; namely, between verbal response time and blunted affect characteristic (n=11, r=.638, p=.035), and between verbal response time and poor rapport (n=11, r=.615, p=.044).

DISCUSSION

This study investigated social response between patients with schizophrenia and a virtual avatar so that we could find the patients' behavioral characteristics to a virtual avatar.

The negative correlation observed in this study is consistent with studies that investigated the relationship between schizophrenic patients' interpersonal distance and their symptoms. In particular, our results of a negative correlation are consistent with a study conducted by Nechamkin et al. showing relationships between the distance and clinical symptomatology, as measured by the PANSS subscales scores.[16] In that study, there was no correlation between positive syndrome scores and any type of interpersonal distances measured with family, friends, and hostile and neutral images, while negative syndrome scores exhibited moderate

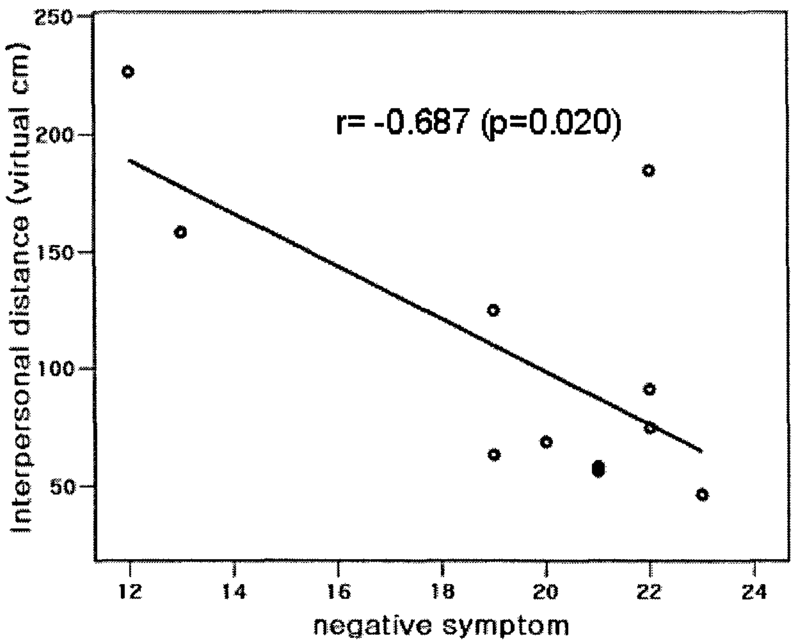


Figure 3. The correlation between patients' negative syndrome scale and the interpersonal distance.

to high negative correlations with the distances measured using hostile and neutral images. Explaining our results based on the Nechamkin's study, patients with schizophrenia perceived the avatar as a neutral or hostile human image. It is reasonable to assume that the patients with schizophrenia probably perceived the avatar as a neutral image of a real person because the avatar did not show any facial expressions and gestures, which means that the avatar showed no emotion to the patients.

The additional parameter we acquired and analyzed in this study was the subject's verbal response time, which was defined as the time elapsed between the patient's response and the avatar's question. Correlation analysis revealed positive correlations between verbal response time and both the blunted affect and poor rapport scales, which are sub-items of the PANSS negative syndrome. The blunted affect score represents the amount of emotional change, which is characterized as the reduction of facial

Subscales in the negative symptoms of PANSS	Correlation value (p value)	
N1: Blunted affect	.638*	.035
N2: Emotional withdrawal	.404	.218
N3: Poor rapport	.615*	.044
N4: Passive/apathetic social withdrawal	.078	.820
N5: Difficulty in abstract thinking	.400	.222
N6: Lack of spontaneity & flow of conversation	–.090	.792
N7: Stereotyped thinking	–.109	.749

* : correlation is significant at the 0.05 level (2-tailed)

Table 1. The correlation between the verbal response time and the subscales in the negative symptoms of PANSS.

expression, emotional modulation, and gesture during communication. By contrast, the poor rapport score represents the amount of intimacy to an interviewer or the level of deficit in forming a relationship, which is characterized as distancing a human relationship and the reduction of verbal and nonverbal communication.[15]

The positive correlation between the verbal response time acquired and subscales in PANSS in this study could be explained by the definition of these subscales. Therefore, this correlation means that the less a patient's emotional response, intimacy, and relationship making with a virtual avatar, the slower they answer the avatar's question. When this fact is considered in view of a virtual avatar, this could be additional evidence to show that a patient with schizophrenia responds to a virtual avatar in the same way as to a real person.

CONCLUSIONS

Our objective for this study was to investigate whether VR is a suitable tool for extracting and assessing the patient's behavioral characteristics. In order to do this, we investigated the behavioral and verbal response characteristics by observing the interpersonal distance between the schizophrenic patients and a virtual avatar, and the duration from the time the avatar asked a question to the time the subject answered, respectively.

This study provided evidence supporting the position that the patients respond to the virtual avatar as if they were really standing near it and conversing. It is also supported by data showing that the patients' behavioral characteristics to a virtual avatar vary in accordance with their symptoms, and these characteristics are the same as those to a real person. This indicates that virtual avatar could draw patient's social response in an objective manner. Therefore, this study could be meaningful because it may provide the method and rationale for applying VR techniques to training or assessing the behavioral and/or cognitive characteristics of patients with schizophrenia.

REFERENCES

[1] D. P. Jang, J. Ku, Y. H. Choi, B. K. Wiederhold, S. W. Nam, I. Y. Kim, and S. I. Kim, "The development of virtual reality therapy (VRT) system for the treatment of acrophobia and therapeutic case," *IEEE Trans Inf Technol Biomed*, vol. 6, pp. 213-7, 2002.

[2] B. O. Rothbaum, L. F. Hodges, R. Kooper, D. Opdyke, J. S. Williford, and M. North, "Effectiveness of computer-generated (virtual reality) graded exposure in the treatment of acrophobia," *Am J Psychiatry*, vol. 152, pp. 626-8, 1995.

[3] B. K. Wiederhold, D. P. Jang, R. G. Gevirtz, S. I. Kim, I. Y. Kim, and M. D. Wiederhold, "The treatment of fear of flying: a controlled study of imaginal and virtual reality graded exposure therapy," *IEEE Trans Inf Technol Biomed*, vol. 6, pp. 218-23, 2002.

[4] A. A. Rizzo, J. G. Buckwalter, L. Humphrey, C. van der Zaag, T. Bowerly, C. Chua, U. Neumann, C. Kyriakakis, A. van Rooyen, and D. Sisemore, "The Virtual Classroom: A Virtual Environment for The Assessment and Rehabilitation Of Attention Deficits," *CyberPsychology and Behavior*, vol. 3, pp. 483-99, 2000.

[5] J. Ku, W. Cho, J. J. Kim, A. Peled, B. K. Wiederhold, M. D. Wiederhold, I. Y. Kim, J. H. Lee, and S. I. Kim, "A virtual environment for investigating schizophrenic patients' characteristics: assessment of cognitive and navigation ability," *Cyberpsychol Behav*, vol. 6, pp. 397-404, 2003.

[6] J. H. Lee, J. Ku, W. Cho, W. Y. Hahn, I. Y. Kim, S. M. Lee, Y. Kang, D. Y. Kim, T. Yu, B. K. Wiederhold, M. D. Wiederhold, and S. I. Kim, "A virtual reality system for the assessment and rehabilitation of the activities of daily living," *Cyberpsychol Behav*, vol. 6, pp. 383-8, 2003.

[7] M. Vidal, M. A. Amorim, and A. Berthoz, "Navigating in a virtual three-dimensional maze: how do egocentric and allocentric reference frames interact?" *Brain Res Cogn Brain Res*, vol. 19, pp. 244-58, 2004.

[8] C. M. Oman, W. L. Shebilske, J. T. Richards, T. C. Tubre, A. C. Beall, and A. Natapoff, "Three dimensional spatial memory and learning in real and virtual environments," *Spat Cogn Comput*, vol. 2, pp. 355-72, 2002.

[9] K. K. Nowak and F. Biocca, "The Effect of the Agency and Anthropomorphism on User's Sense of Telepresence, Copresence, and Social Presence in Virtual Environments," *Presence: Teleoperators and Virtual Environments*, vol. 12, pp. 481-494, 2003.
[10] J. N. Bailenson, J. Blascovich, A. C. Beall, and J. M. Loomis, "Interpersonal distance in immersive virtual environments," *Pers Soc Psychol Bull*, vol. 29, pp. 819-33, 2003.
[11] J. Blascovich, J. Loomis, A. Beall, K. R. Swinth, C. Hoyt, and J. N. Bailenson, "Immersive Virtual Environment Technology as a Methodological Tool for Social Psychology," *Psychological Inquiry*, vol. 13, pp. 103-124, 2002.
[12] S. K. Schultz and N. C. Andreasen, "Schizophrenia," *Lancet*, vol. 353, pp. 1425-30, 1999.
[13] "Diagnostic and statistical manual of mental disorders, 4th edition (DSM-IV)," American Psychiatric Press, Washington, DC 1994.
[14] H. C. Chien, C. H. Ku, R. B. Lu, H. Chu, Y. H. Tao, and K. R. Chou, "Effects of social skills training on improving social skills of patients with schizophrenia," *Arch Psychiatr Nurs*, vol. 17, pp. 228-36, 2003.
[15] S. R. Kay, A. Fiszbein, and L. A. Opler, "The positive and negative syndrome scale (PANSS) for schizophrenia," *Schizophr Bull*, vol. 13, pp. 261-76, 1987.
[16] Y. Nechamkin, I. Salganik, I. Modai, and A. M. Ponizovsky, "Interpersonal distance in schizophrenic patients: relationship to negative syndrome," *Int J Soc Psychiatry*, vol. 49, pp. 166-74, 2003.

Contact

Jeonghun Ku
133-605 Dept. of Biomedical Engineering,
Hanyang University
Sung Dong P.O. Box 55
Seoul, Korea
Tel : +82-2-2290-0693
Fax : +82-2-2296-5943
kujh@bme.hanyang.ac.kr

Spatial Ability and Navigation Learning in a Virtual City

J-H. Lee, Ph.D.[1,2], R. Mraz, B.A.Sc.,P.Eng.[2], K. K. Zakzanis, Ph.D.[3], S. E. Black, M.D.,Ph.D.[4], P. J. Snyder, Ph.D.[6], S. I. Kim, Ph.D.[1], and S. J. Graham, Ph.D., P.Eng.[2,5]

[1] Department of Biomedical Engineering, Hanyang University, Seoul, Korea
[2] Imaging Research, Sunnybrook & Women's College Health Science Centre, Toronto, ON, Canada
[3] Division of Life Sciences, [4] Department of Medicine-Neurology, and [5] Department of Medical Biophysics, University of Toronto, ON, Canada
[6]Pfizer Global Research & Development, Groton, CT, USA

Abstract: *Background & Significance of the Problem: Virtual environments (VEs) can be used to assess spatial memory and navigation skills, although the behaviour elicited is inherently complex. The purpose of this study was to investigate the ecological validity and interrelationship between virtual navigation tasks and several neuropsychological tests.*

Methods/Tools: Forty-two participants (mean age: 70.42) took part in the study, of which eighteen were recruited from the Cognitive Neurology Clinic at Sunnybrook & Women's College Health Sciences Centre (S&W) based on diagnosis of mild cognitive impairment (MCI). Subjects completed the Groton Maze Learning Test (GMLT; a hidden maze task developed by one of the authors [P.J.S.]) and several neuropsychological tests, including the MMSE,[1] the Rey Complex Figure Test,[2] Benton Visual Retention test,[3] Trail-Making Test (Forms A and B),[4] and Digit Span.[5] Sixteen of the participants (9 normal, 7 MCI) also undertook a VE navigation task.[6] Behaviour elicited by the VE task was characterized in terms of two components, as estimated by factor analysis: a VE memory index, and a VE movement index.

Results: The VE memory index was significantly associated with the results of a conventional memory test (Rey Complex Figure), and the VE movement index was significantly associated with measures of the Trail Making Test. Compared with normal participants, participants with mild cognitive impairment (MCI) showed a significant reduction in the memory-related measures in the PGRD Maze Learning Test and memory tests (particularly RCFT), and the MCI group deviated significantly from the correct route, particularly in novel environments. Performance in the VE navigation-learning task was significantly associated with measures of visual memory and the executive function in conventional neuropsychological tests.

Conclusion: The results of this study demonstrate that VE technology can be used to assess spatial memory and navigation skills, and that measures of this behavior in a VE are related to those of conventional neuropsychological tests. Our results also demonstrate that the MCI group showed a significant reduction in memory-related measures in the GMLT and the neuropsychological tests. In particular, differences between the groups were evident in the immediate and delayed recall in the Rey Test. However, because of the small sample size, statistically significant results were not found between groups in the VE navigation task.

Novelty: The interrelationship between the VE task, the GMLT, and neuropsychological assessments is important for administration and interpretation of these computerized tests in the future.

Recently, the development of virtual environment (VE) technology has enabled a systematic and laboratory-based investigation of spatial navigation in humans.[1] VE technology has been used successfully to assess the acquisition of spatial knowledge,[2] sex differences in spatial navigation,[3] theta oscillations in electroencephalography,[4] age changes in route learning,[5] and regional brain activation patterns in neuroimaging studies.[6] However, VEs have limitations in such research: typically, participants must perform solely on the basis of visual information and must become familiar with the use of interfaces such as a mouse or joystick to direct movements. Nevertheless, it has been shown that cognitive maps developed using VEs are comparable to those acquired in the real environment.[7] Several studies have confirmed that representations learned in VEs are transferable to real space.[8]

Recent efforts to study human spatial memory and navigation have involved the use of maps or model environments. For example, Galea and Kimura[9] required participants to learn a route through a town drawn on a large sheet of paper. Although the elements of such an environment can be well controlled by the experimenter, it is not clear that learning a route by perusing a 2D drawing of an environment uses the same spatial skills as navigating in a more ecologically valid environment.[10] Many studies suggest that such navigation is not the same as a table-top test of spatial memory, and that direct inferences cannot be made about one from the other. On a table-top, all information is within one field of view (i.e., allocentric perspective); this is not the case in a complex environment, in which much of the relevant information is unseen at any specific time (i.e., egocentric perspective).[1] Patients with topographical memory impairment, who present with well intact table-top spatial and geographical knowledge tests, have been described in the literature.[11] The opposite type of impairment has also been observed. Maguire and Cipolotti[12] reported a patient with selective preservation of navigation ability in the context of profound verbal and visual memory impairment and poor geographical knowledge, confirming the double dissociation between navigation and table-top spatial tasks. There have been few studies investigating the ecological validity of tests of spatial skill. Sonnenfeld[13] concluded that paper-and-pencil spatial performance is independent of true wayfinding or navigation ability. Kirasic[14] found no significant relationship between elderly individuals' performance on psychometric tasks and their navigation ability. However, she found that performance on a photographic-slide route-simulation task correlated significantly with real-world spatial performance. Recently, Nadolne and Stringer[15] reported that from a battery of clinical tests administered to stroke patients, one test of visual memory correlated with an environment-specific directional-orientation criterion task, but no clinical test correlated with route navigation ability. In addition, performance on a task based on ecological simulation correlated well with route navigation ability. Collectively, these studies first suggest that tasks simulating the spatial environment realistically may have greater ecological validity than traditional psychometric measures. Second, they indicate the need for further validation of ecological simulation tasks.

To summarize, computer-simulated 3D VEs have recently been shown to measure human navigational abilities and spatial memory successfully in reasonably realistic settings that are both novel and well controlled. In this study, we investigate the relationship between a virtual navigation-learning task, several neuropsychological tests that measure visual memory abilities, and a computerized, table-top maze-learning test that measures spatial memory and learning. Participating in the study were a group of healthy elderly adults, as prior studies of navigation have demonstrated that elderly adults show more difficulty than younger adults in learning and retrieving routes.[16] A second group included patients with selective memory complaints and diagnosed with mild cognitive impairment according to standard criteria.

METHODS

Participants

Forty-two participants (32 healthy elderly, 18 MCI patients) with a mean age of 70.42 (±7.75) years (range 58–84 years) were recruited from the Cognitive Neurology Clinic at Sunnybrook & Women's College Health Sciences Centre (S&W) in Toronto. The two groups were

matched with respect to their scores on the Mini-Mental State Examination (MMSE), years of education, and age. All were paid US$50 for participating. Only a subset participated in the VE task, and within this group the data for 14 participants were lost as a result of a computer malfunction and withdrawals from the study because of nausea or dizziness induced by VE exposure. The final sample size for the navigation trials in the VE was 16 (9 healthy elderly, 7 MCI patients).

Neuropsychological Tests

Each participant performed: the Rey-Osterieth Complex Figure Test (RCFT; copy, immediate recall, delayed recall); the Trail Making Test (A and B); the Digit Span subtest (forwards and backwards) from the Wechsler Adult Intelligence Scale-Revised; the Dementia Rating Scale (total, attention, initiation, construction, conceptualization, and memory components); and the Mini-Mental Status Examination.

The PGRD Maze Learning Test

The PGRD Maze Learning Test,[17] a computer-based neuropsychological measure of immediate- and short-term retention of visuospatial information, is based on the original work of Milner.[18] The goal is to learn over a series of trials how to navigate from table-top perspective through a hidden maze and capture a target. Participants pressed on a touch-screen to reveal the maze under a matrix of tiles. There were untimed and timed components for either a 4 × 4 or a 10 × 10 Chase Test.

VE Navigation-learning Task

A virtual city (adapted from Mraz et al.[19]) was created in which the user could navigate using a projection screen, a 6-DOF head tracker, and a joystick. Participants were initially trained to move in virtual space by traversing an elementary maze consisting of 12 turns over a fixed distance. Subsequently, participants were shown a path through the city with video playback in egocentric perspective, and alternately watched the route or attempted to navigate it themselves. They were instructed to navigate as accurately as possible without bumping into objects, to pay attention to "the rules of the road" by staying on the sidewalk, and to pay attention to where various objects in the city were located with respect to each other. A set of three learning trials was performed for one path (Path A), followed by one learning trial for a second path (Path B). Short delay (5 min.) and long delay (20 min.) recall trials were also performed, during which Path A was navigated from memory.

PROCEDURES

Informed consent was obtained from each participant, based on approval of the S&W Research Ethics Board. Data collection for all participants occurred in the following order: (1) the CDR and the MMSE; (2) the neuropsychological tests; (3) the PGRD Maze Learning Test (Trials 1 to 10, delay, and reverse); (4) the VE navigation-learning task followed by completion of the Simulator Sickness Questionnaire[20]. Statistical analysis was performed using commercial software (SPSS 11.0).

RESULTS

An index of memory was estimated from the neuropsychological tests by factor analysis: memory index=0.934×Z(Rey delayed recall) +0.904×Z(Rey immediate recall)+ 0.611×Z (forward digit span)+0.530×Z(CDR memory). Internal consistency of the memory index was α= 0.772. This memory index and the data from learning tests were compared to determine whether performance on paper-and-pencil tests was similar to that on the computerized tests. Consistently high and significant correlations were found between the memory index and measures of the PGRD Maze Learning Test. In contrast, only two measures of the VE task were significantly correlated with the memory index: time to completion on Trial 1 and Long Delay Recall. This initial finding was then used to perform an additional factor analysis providing an overall VE navigation index, consisting of a memory component and a movement component. The VE movement index was composed of measures in only Trial 1 (distance traveled and wrong turn metrics, specifically excluding time) because the other trials involved repeated exposure:

VE memory index = Z(long delay time) + Z(Trial 1 time)

	VE navigation	VE movement	VE memory
VE movement	0.94**		
VE memory	0.58*	0.32	
Memory index	-0.24	-0.13	-0.55*
Rey immediate recall	-0.25	-0.12	-0.60**
Rey delayed recall	-0.21	-0.05	-0.54*
Trail Making Test A	0.35	0.46**	0.08
Trail Making Test A error	0.49	0.41*	0.08
Trail Making Test B error	0.58*	0.47**	0.23

p<0.05, ** p<0.01

Table 1. Pearson Correlations between the VE indexes and Neuropsychological Tests

VE movement index = 0.870×Z(wrong turn) + 0.734×Z(distance) + 0.598×Z(double wrong turn)
VE navigation index = VR memory index + VR movement index

The VE indices were subsequently analyzed to confirm the validity with the neuropsychological tests. Table 1 illustrates that the VE navigation index was more highly correlated with the VE movement index than with the VE memory index, and showed significant correlation with the Trail Making Test (A error, and B error), which measured an executive function and visuomotor tracking. The VE movement and memory indices were not statistically correlated with each other. The VE movement index also was significantly correlated with the TMT measures (A, A error, B error), whereas the VE memory index was correlated with measures of the Rey immediate recall and delayed recall.

A two-factor repeated-measures ANOVA was used to analyze the measures across the trials of the PGRD test and the VE navigation-learning task, for both normal and MCI groups. With respect to the PGRD test, a significant main effect of the trials was revealed for completion time, $F(1,37)=84.595$, $p<0.01$, indicating improved performance as the trials progressed. There was no effect of group (normal versus MCI) on overall performance, nor was there an interaction between group and trial number. Other measures (movement, error, and perseveration) of the PGRD test gave the same results. On some specific measures that were difficult or required greater memory resources, however, such as the delay and reverse tests, there were significant differences between healthy elderly and MCI patients. These findings were mirrored in the neuropsychological tests and are shown in Table 2.

For the VE navigation-learning test, a significant main effect of trials for completion time and single wrong turns was found: $F(1,12)=12.725$, $p<0.01$; $F(1,12)=7.824$, $p<0.05$, respectively. As

	Variables	Normal	MCI	t
PGRD maze learning test	Trial2_rule break	0.26±0.45	0.83±1.04	-2.372*
	Delay time	41.05±14.36	55.95±23.81	-2.52*
	Reverse time	46.95±16.57	65.98±25.51	-2.82**
Neuropsychological tests	CDR total	140.00±3.12	137.28±4.82	2.22*
	CDR initiation	36.67±0.64	35.33±2.40	2.61**
	Rey Immediate Recall	18.94±6.13	11.33±6.39	3.90**
	Rey Delayed Recall	18.58±5.53	10.62±5.93	4.41**
	Memory index	52.56±11.00	37.77±11.68	4.14**

* p<0.05, ** p<0.01

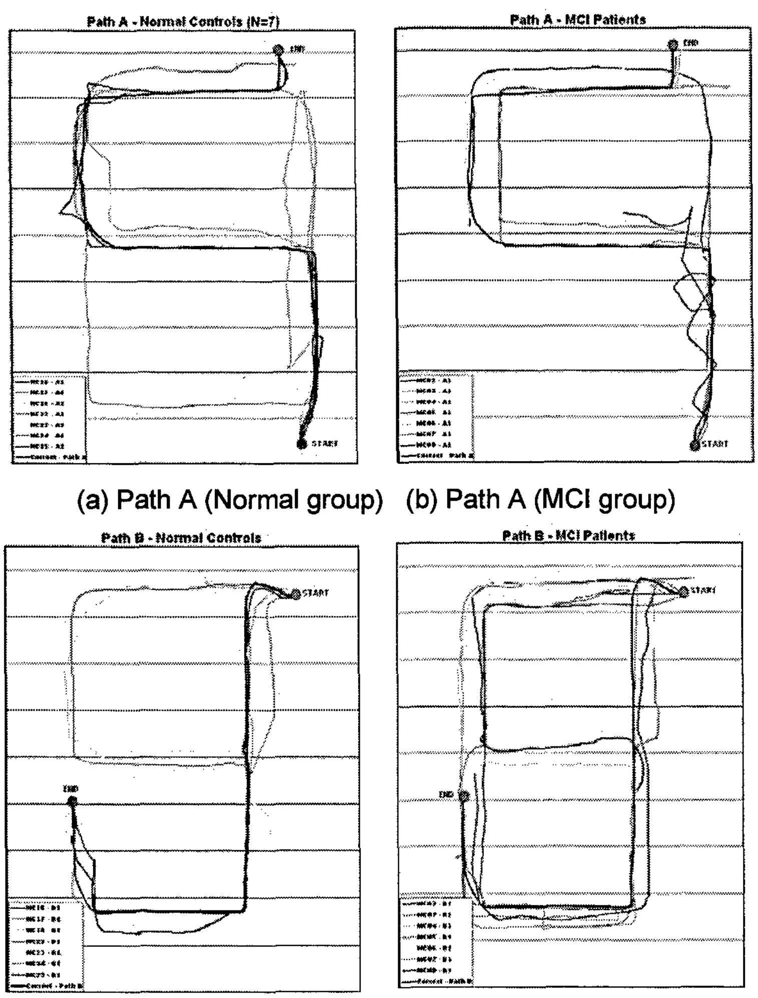
Table 2. Performance of Normal and MCI Groups on Tests (summarized results)

above, there were no group or interaction effects. No specific measures showed significant differences between the groups analogous to those shown in Table 2.

DISCUSSION

The results of this paper demonstrate that VE technology can be used to assess spatial memory and navigation skills, and that the measures of this behavior in a VE are related to those of newer and conventional neuropsychological tests. The VE *memory* index was related to the RCFT (immediate and delayed), but the VE *movement* index was related to the Trail Making Test, which is known to assess visuomotor skills and executive function. The VE memory index was strongly correlated with the time variables of the PGRD Maze Learning Test and the memory index of the neuropsychological tests (from Trials 2 to 9, r=0.514~0.625). These results suggest that navigational-learning in a VE is very useful in the assessment of spatial memory. Although not directly assessed in this study, it is likely that the VE navigational-learning task can provide reliable and valid measures of real-world functional abilities. Additional research is required to address this question.

Several results suggest that clinically relevant impairments in navigation skills, spatial orientation, and memory are often apparent in the early stages of dementia and MCI.[21] Our results demonstrate that the MCI group showed a significant



(a) Path A (Normal group) (b) Path A (MCI group)

(c) Path B (Normal group) (d) Path B (MCI group)

Figure 1. The navigational routes taken by participants.

reduction in a subset of the memory-related measures in the PGRD Maze Learning Test and in the neuropsychological tests. In particular, differences between the groups were evident in the immediate and delayed recall in the RCFT. These results were not observed for the VE navigation-learning task, which could be due to the reduced sample size for this component of the study. It is also of interest to visualize the navigational differences between the groups when performing the VE task (Figure 1).

Although most of the normal group (except two participants) did not deviate from the correct path, the MCI group tended to deviate from the correct path, particularly Path B (Figure 4(d)). These results suggest that the MCI group encountered greater difficulty than the normal group in the novel environments. They also highlight one of the recognized challenges in the interpretation of behavior elicited in virtual environments. Given that the behavior can be complex, it is likely that characterizing behavior in terms of simple metrics such as time to completion fails to encapsulate the richness of the data.

Although there are no differences in the effects of sex in the current study, studies with larger sample sizes across the groups are needed before it can be definitively concluded that MCI groups have inferior spatial memory and navigation skills irrespective of age and sex. Future studies need to investigate how age, sex, and strategy affect spatial memory and navigation learning in normal, MCI, and Alzheimer patients.

ACKNOWLEDGMENTS

This work was supported through grants from Pfizer, Inc., the Canadian Foundation for Innovation, the Ontario Premier's Research Excellence Award, and the Ontario Research and Development Challenge Fund. The authors thank Le-Anh Ngo and Mark Boulos for their assistance in testing the participants.

References

1. Maguire, E. A., Burgess, N., & O'Keefe, J. (1999). Human spatial navigation: cognitive maps, sexual dimorphism, and neural substrates. *Current Opinion in Neurobiology* 9:171–177.
2. Gillner, S., & Mallot, H.A. (1998). Navigation and acquisition of spatial knowledge in a virtual maze. *Journal of Cognitive Neuroscience* 10:445–463.
3. Astur, R.S., Ortiz, M.L., & Sutherland, R.J. (1998). A characterization of performance by men and women in a virtual Morris water task: a large and reliable sex difference. *Behavioural Brain Research* 93:185–190.
4. Kahana, M.J., Sekuler, R., Caplan, J.B., Kirschen, M., & Madsen, J.R. (1999). Human theta oscillations exhibit task dependence during virtual maze navigation. *Nature* 399:781–784.
5. Moffat, S.D., Zonderman, A.B., & Resnick, S.M. (2001). Age differences in spatial memory in a virtual environment navigation task. *Neurobiology of Aging* 22:787–796.
6. Gron, G., Wunderlich, A.P., Spitzer, M., Tomczak, R., & Riepe, M.W. (2000). Brain activation during human navigation: gender-different neural networks as substrate of performance. *Nature Neuroscience* 3:404–408.
7. Ekstrom, A.D., Kahana, M.J., Caplan, J.B., Fields, T.A., Isham, E.A., Newman, E.L., & Fried, I. (2003). Cellular networks underlying human spatial navigation. *Nature* 425 (6954):184-188.
8. Regian, J.W., & Yadrick, R.M. (1994). Assessment of configurational knowledge of naturally- and artificially-acquired large-scale space. *Journal of Environmental Psychology* 14:211–223.
9. Galea, L.A.M., & Kimura, D. (1992). Sex differences in route-learning. *Personality and Individual Differences* 14:53–65.
10. Sandstrom, N.J., Kaufman, J., & Huettel, S.A. (1998). Males and females use different distal cues in a virtual environment navigation task. *Cognitive Brain Research* 6:351–360.
11. McCarthy, R.A., Evans, J.J., & Hodges, J.R. (1996). Topographic amnesia: spatial memory disorder, perceptual dysfunction, or category specific semantic memory impairment? *Journal of Neurology Neurosurgery and Psychiatry* 60:318–325.
12. Maguire, E.A., & Cipolotti, L. (1998). The selective sparing of topographical memory. *Journal of Neurology Neurosurgery and Psy-*

chiatry 65:903–909.

13. Sonnenfeld, J. (1985). Tests of spatial skill: A validation problem. *Man-Environment Systems* 15:107–120.
14. Kirasic, K.C. (1988). Aging and spatial cognition: current status and new directions for experimental researchers and cognitive neuropsychologists. In J.M. Williams & C.J. Long (eds.), *Cognitive Approaches to Neuropsychology*. New York: Plenum.
15. Nadolne, M.J., & Stringer, A.Y. (2001). Ecologic validity in neuropsychological assessment: prediction of wayfinding. *Journal of the International Neuropsychological Society* 7:675–682.
16. Kirasic, K.C. (1991). Spatial cognition and behavior in young and elderly adults: implications for learning new environments. *Psychological Aging* 6(1):10–18.
17. Peter J. Snyder (2001). *PGRD Maze Learning Test*. Pfizer Inc.
18. Milner, B. (1965). Visually-guided maze learning in man: Effects of bilateral hippocampal, bilateral frontal, and unilateral cerebral lesions. Neuropsychologia, 3, 317-338.
19. Mraz, R., Hong, J., Quintin, G., Staines, W.R., McIlroy, W.E., Zakzanis, K.K., Graham, S.J. (2003). A platform for combining virtual reality experiments with functional magnetic resonance imaging. *CyberPsychology & Behavior* 6(4):359-368.
20. Kennedy, R., Lane, N., Berbaum, N., & Lilienthal, M. (1993). A Simulator Sickness Questionnaire (SSQ): A New Method for Quantifying Simulator Sickness. *International Journal of Aviation Psychology* 3:203-220.
21. Passini, R., Rainville, C., Marchand, N., & Joanette, Y. (1995). Wayfinding in dementia of the Alzheimer type: planning abilities. *Journal of Clinical and Experimental Neuropsychology* 17(6):820–832.

Contact

Simon J. Graham, Ph.D., P.Eng.
S650-Imaging Research
Sunnybrook & Women's College Health Sciences Center
2075 Bayview Ave.
Toronto, ON, M4N 3M5 Canada
Email: simon.graham@sw.ca

Telepsychiatry:
Psychiatric Consultation through Videoconference Clinical Results

C. De las Cuevas PhD, MD

Department of Psychiatry. University of La Laguna
Canary Islands Health Service

Abstract: Main Outcome Measures: *Efficacy variables included scores on the Clinical Global Impressions-Severity of Illness (CGI-S) and -Improvement (CGI-I) scales as well as Global Indexes (GSI, PSDI and PST) from SCL-90R. Response was defined as a CGI-I score of 1 or 2. Reliable Change Indexes were computed in SCL-90R Global Indexes scores. A multivariate logistic regression analysis was carried out to evaluate the effect of each factor associated with the success of telepsychiatry.*

Results: *With respect to baseline severity of illness, the overall average Clinical Global Impression (CGI-S) score was between 4 (moderately ill) and 5 (markedly ill). Only 4 patients dropped-out prematurely the study. The patients' mean SCL-90-R Global Indexes scores decreased over time, indicating less psychiatric distress. Significant decreases from baseline to week 24 were obtained in psychiatric status. A significant proportion of patients showed clear clinical state improvement. Multivariate logistic regression analysis shows that telepsychiatry was effective independently of gender, age, educational level, ICD-10 diagnosis, initial severity of illness or the presence of antecedents of previous psychiatric disorders and treatments.*

Conclusion: *Telepsychiatry showed to be an effective mean of delivering mental health services to psychiatric outpatients living in remote areas with limited resources.*

INTRODUCTION

Telepsychiatry can be conceived as an integrated system of mental health care delivery that employs telecommunications and computerized information technology as an alternative to face-to-face conventional modality. Videoconferencing is the central technology currently used in telepsychiatry, since it permit live, two-way interactive, full-colour, video, audio and data communication. Telepsychiatry, in the form of videoconferencing, has been well received in terms of increasing access to care and user satisfaction.[1,2] Questions persist, however, about its effectiveness since there are few clinical outcome studies and because there may also be a positive reporting bias in the literature.[3]

The Canary Islands Health Service developed in 2003 a telepsychiatry programme to complement the mental health-care of the citizens living on La Gomera island with the objectives of improving access, reducing isolation and improving the quality of mental health care in this area. This new system of service delivery was possible thanks to a research grant (EU QLRT-2001-0167 – ISLANDS Project) from the European Union. In order to investigate the effectiveness of a routine telepsychiatry service through videoconferencing a prospective cohort study of a sample of 70 psychiatric outpatients was carried out.

MATERIAL AND METHODS

The telepsychiatry service provides psychiatric consultations to individuals after referral from a general practitioner. A patient living in La Gomera with a mental health problem can choose between joining the waiting list to see the visiting psychiatrist, that travel every Monday from Tenerife island, or being included in the telepsychiatry programme. Telepsychiatry sessions take place every Thursday from 9:00 to 13:00. Emergency access is available from Monday to Friday (8:00 to 15:00). After the teleconsultation, recommendations are provided directly to

Table 1. Sociodemographic and clinical characteristics of the sample studied

Variable	Category	Number of cases	% of sample	% 24 week CGI–Sev ≤ 2	% 24 week CGI– Imp ≤ 2
Age					
	< 25 years	12	17.1	91.7	100
	25-45 years	37	52.9	67.6	78.3
	45-65 years	16	22.9	50	68.7
	> 65 years	5	7.1	60	80
Gender					
	Male	22	31.4	72.7	86.4
	Female	48	68.6	64.6	77.1
Educational level					
	Can read and write	11	15.8	63.6	81.8
	Primary studies	33	47.1	95.6	78.8
	College	13	18.6	46.1	69.2
	University degree	13	18.6	92.3	92.3
ICD-10 Diagnosis *					
	F1	5	7.1	80	80
	F2	5	7.1	80	80
	F3	23	32.9	47.8	69.6
	F4	31	44.3	77.4	83.9
	F6	6	8.6	66.6	100
CGI – Severity of Illness					
	Moderatelly ill	8	11.4	62.5	62.5
	Markedly ill	61	87.1	68.8	83.6
	Severely ill	1	1.4	0	0
Total		70	100	67,2%	80%

* **ICD-10 Diagnoses**
(F1): Mental and behavioural disorders due to psychoactive substance abuse
(F2): Schizophrenia, schizotypal and delusional disorders
(F3): Mood (affective) disorders
(F4): Neurotic, stress-related and somatoform disorders
(F6): Disorders of the adult personality and behaviour

% 24 week CGI – Sev ≤ 2: Proportion of patients with CGI Severity of Illness score ≤ 2 (1= normal, not at all ill; 2=borderline, mentally ill) at week 24.
% 24 week CGI – Imp ≤ 2: Proportion of patients with CGI Global Improvement score ≤ 2 (1= very much improved; 2= much improved) at week 24.

the patient's GP via email. Telepsychiatry consultations use commercial videoconferencing equipment (Viewstation 512, Polycom®) connected via ISDN lines at up to 512 kbit/s.

PATIENTS

The sample comprised 70 psychiatric outpatients patients, with 66.3% female and 33.7% male, which were followed up through 24 weeks. The mean age was 39.8±15 years (range 15–80). Women registered a higher mean age than men (42.9±15 vs. 33.2±12). Patients were diagnosed according to ICD-10 criteria. Anxiety disorders were the more prevalent diagnosis. Most of the patients (87.1%) included were markedly ill at the beginning and the majority of them (67.1%) have antecedents of previous psychiatric treatments in face-to-face alternative. Of 70 patients included in the study, only 4 dropped-out prematurely. Other socio-demographic and clinical characteristics of the sample studied are shown in Table 1.

TREATMENT

The telepsychiatry treatment was conducted by videoconference between the University Hospital de la Candelaria in Santa Cruz de Tenerife (psychiatrist location) and the Mental Health Care Health Centre of San Sebastian de la Gomera. (Patients location). Treatment involves at least 6 sessions lasting 30 minutes over the 24 week study period. Additional treatment sessions take place if clinically indicated. The treatment consists of pertinent psychotropic medication plus cognitive-behavioural treatment and psychological evaluation concerning the disease, medications, and side effects. The mean number of psychoactive drugs prescribed was 1.76±0.84 (range 0-4). Antidepressants were the most prescribed drugs (74.3%), followed by benzodiazepine tranquillisers (72.9%) and antipsychotics (14.3%).

INSTRUMENTS

The efficacy of treatments received was measured by changes in the Symptom Checklist-90 Revised (SCL-90R)[4] global distress indices and Clinical Global Impression (CGI) (NIMH, 1970) ratings at weeks 0, 4, 8, 12, 16, 20 and 24.

The Symptom Checklist-90 Revised is a standardized multidimensional 90-item self-report symptom inventory covering various dimensions of psychological distress. Each item is rated on a 5-point scale of distress, ranging from not at all (0) to extremely (4). It utilizes three global distress indexes: Global Severity Index (GSI), Positive Symptom Distress Index (PSDI) and Positive Symptom Total (PST). The GSI combines the number of symptoms reported and intensity of reported distress to yield the single best descriptor of current mental health. The PSDI represents the average level of distress reported for symptoms endorsed and the PST reflects the total number of symptoms reported regardless of symptom intensity. Normative data for Canary Islands citizens were available and were used to calculate reliable changes indexes.

Clinical Global Impression is a three-item scale used to assess treatment response in all categories of psychiatric patients. It was administered by patient's psychiatrist and 2 minutes are enough to complete. The items are: Severity of Illness; Global Improvement and Efficacy Index. Item 1 is rated on a seven-point scale (1=normal to 7=extremely ill); item 2 on a seven-point scale (1=very much improved to 7=very much worse); and item 3 on a four-point scale (from 'none' to 'outweighs therapeutic effect').

PROCEDURE

In the same way that Jacobson and Truax,[5] we defined "reliable change" in terms of the reliability of the measurement instruments used. We considered that the error variance in a set of scores that is due to the unreliability of the scale is the *standard error of measurement*. Scales that are highly reliable will have a small standard error of measurement. If we know the reliability of the scale (typically measured as Cronbach's alpha) and the standard deviation of the raw scores on that scale we can find the expected standard deviation of the variability of the error scores. The formula for the standard error measurement is:

$$SE_{meas} = \sigma_{meas} = SD * \sqrt{1 - r_{11}}$$

Where SD = the standard deviation of the measure, and r_{11}= the reliability (typically coefficient alpha) of the measure.

A Reliable Change Index (RCI) is computed by dividing the difference between the pretreatment and posttreatment scores by the standard error of the difference between the two scores. If the RCI is greater than 1.96, then the difference is reliable, a change of that magnitude would not be expected due to the unreliability of the measure. Conversely, if the RCI score is 1.96 or less then the change is not considered to be reliable, it could have occurred just due to the unreliability of the measure.

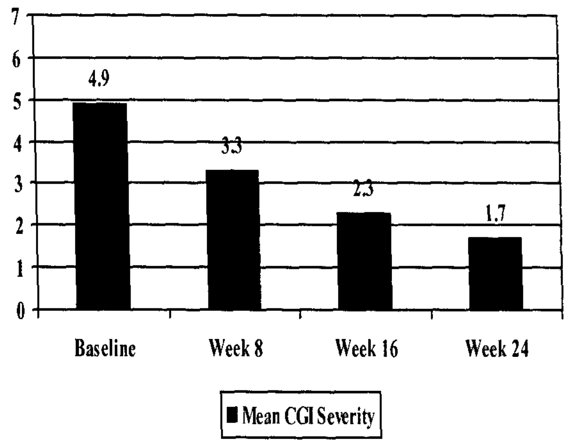
$$RCI = (posttest - pretest) / SE_{meas}$$

In order to evaluate the effect of each factor associated with the success of telepsychiatry, a multivariate logistic regression analysis was carried out.

RESULTS

Clinical changes in CGI Severity and Improvement scores after treatment via telepsychiatry are provided in Table 1. This shows that telepsychiatry was effective in significantly reducing clinical measures of severity as determined by a CGI change score of 2 or less (normal, not at all ill or borderline, mentally ill) in 67.2% of the sample at week 24. In the same way, 80% of the patients included in the study were "much" or "very much" improved on the clinical global impression scale. Figure 1 shows the mean CGI Severity of Illness scores at baseline, week 8, week 16 and week 24.

Figure 1. Mean CGI Severity of Illness scores at baseline, week 8, week 16 and week 24



The patients' mean SCL-90-R Global Indexes scores decreased over time, indicating less psychiatric distress. Statistical summaries of the data, including reliable change index data, are displayed in Table 2. Only 3% of patients that finished the 24 weeks follow up reported a reliable deterioration in their mental health status according GSI, while 22.7% reported uncertain changes at the end of the videoconferencing treatment period. 74.3% of patients reported a reliable improvement in their CGI scores, being 45.5% recovered. Concerning the level of distress informed, 68.1% of the patients reported reliable improvements, being 62.1% recovered. Considering the total number of symptoms reported, 52.1% informed reliable improvement, being only 39.6% recovered. It is

Table 2. Reliable Change Index Summary Statistics of SCL-90R Global Indexes

(*n* = 66)	Reliable deterioration		Uncertain change		Reliable improvement - not recovered		Reliable improvement-recovered		% Moved from above cutoff score at pretest to below cutoff score at follow-up	
Measure	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
SCL-90R GSI	2	3	15	22,7	19	28,8	30	45,5	35 of 66	53
SCL-90R PSDI	2	3	19	28,8	4	6	41	62,1	54 of 66	82
SCL-90R PST	1	1,5	30	45,4	11	13,5	24	39,6	30 of 66	45,5

Variable	Statistic value of Wald	Degrees of Freedom	P value of Wald
Gender	2,454	1	,117
Age	2,296	1	,130
Educational Level	3,741	5	,587
ICD-10 Diagnoses	,428	4	,980
Antecedents	,041	1	,839
Severity of Illness	,299	2	,861

Table 3. Multivariate logistic regression analysis results. Variables in the equation

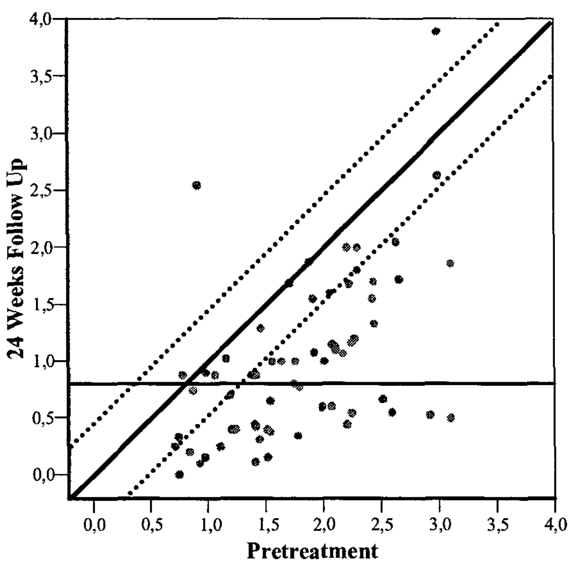


Figure 2. Graphic Representation of Reliable Change Index in Global Severity Index

Reliable deterioration are those cases in the upper right triangle, outside of the band of no reliable change. Uncertain change are those participants within the band of no reliable change. Reliable improvement - not recovered are individuals to the right of the band of no reliable change and above the 1 SD cutoff score. Reliable improvement - recovered are individuals to the right of the band of no reliable change and below the 1 SD cutoff score.

necessary to consider that almost all patients received drug treatments that involve adverse effects that bias this figures.

None of the variables included in the study influenced in a significant way the success of the treatment (Table 3). Neither the gender, nor the age or the educational level of the patients showed statistically significant differences in the rate of telepsychiatry success. In the same way, neither the diagnosis of the patient, nor the existence of antecedents of previous psychiatric disorders treated, or the severity of the illness the beginning of treatment influenced the success of the telepsychiatry treatment.

As conclusion of the exposed results, telepsychiatry showed to be an effective mean of delivering mental health services to psychiatric outpatients living in remote areas with limited resources. Its clinical efficacy was not conditioned by any of the analysed variables.

REFERENCES

1. Mair F, Whitten P. Systematic review of studies of patient satisfaction with telemedicine. BMJ 2000; 320;1517-1520
2. De las Cuevas C, Artiles J, De la Fuente J, Serrano P: Telepsychiatry in the Canary Islands: user acceptance and satisfaction. J Telemed Telecare 2003, 9 (4): 221-224
3. Hilty DM, Liu W, Marks S, Callahan EJ. The Effective ness of Telepsychiatry: A Review. CPA Bulletin de l'APC, October 2003: 10-17.
4. Derogatis, L. R. (1992). *SCL-90-R: Administration, scoring and procedures manual--II.* Baltimore: Clinical Psychometric Research.

Figure 3. Graphic Representation of Reliable Change Index in Positive Symptom Distress Index

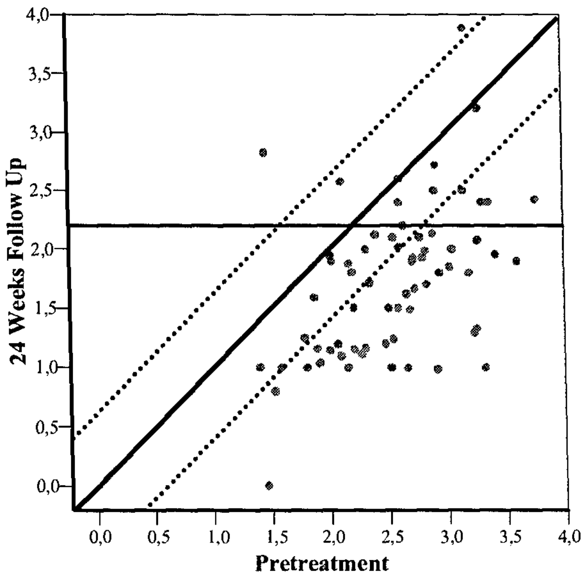
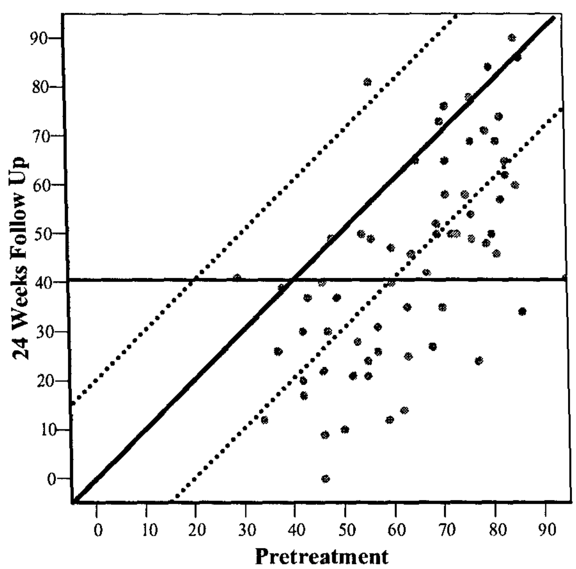


Figure 4. Graphic Representation of Reliable Change Index in Positive Symptom Total



National Institute of Mental Health. CGI: Clinical Global Impressions. In: Guy W, Bonato RR, eds. Manual for the ECDEU Assessment Battery.2. Rev ed. Chevy Chase, Md: National Institute of Mental Health; 1970:12-1-12-6.

5. Jacobson N S, Truax P. Clinical significance: A statistical approach to defining meaningful change in psychotherapy research. *Journal of Consulting and Clinical Psychology 1991, 59,* 12-19.

Contact

Prof. Carlos De las Cuevas PhD MD
Urbanización Las Cañas, 33
38208 La Laguna, Tenerife
Canary Islands, Spain
ccuevas@ull.es

Training Blind Children to Develop Mathematics Skills Through Audio

J. Sánchez, H. Flores

Department of Computer Science
University of Chile

Abstract: *A number of studies using computer applications have been designed to improve learning in children with visual disabilities. Some research studies use audio-based interactive interfaces to enhance learning and cognition in children with visual disabilities. The development of mathematics learning through virtual environments has not been studied in the literature. This work presents the design, development, and usability of two audio-based virtual environments: AudioMath and Theo & Seth, interactive virtual environments based on audio to develop mathematics learning of children with visual disabilities. AudioMath and Theo & Seth were developed by and for blind children. They participated in the design and usability tested the software during and after implementation. Our results evidenced that audio embedded into virtual environments can be a powerful interface to develop mathematics learning in blind children.*

INTRODUCTION

Virtual environments based on audio to foster learning and cognition has been increasingly developed for people with visual disabilities. Diverse studies have focused on the design of audio-based interfaces and evaluated their impact on learning and cognition.[1-8] Most of them are based on interactive software that cannot be fully adapted to their needs and requirements. Actually, some of them are fixed prototypes without enough flexibility and versatility.
A seminal study developed the first proof-of-concept application to navigate virtual environments through audio by blind children.[2] The study used audio to enhance spatial cognitive structures and found that spatial sound can be used to develop spatial navigation skills in a virtual environment. Some studies designed experiences with audio stimuli to simulate visual cues for blind learners,[4] finding that by using 3D audio interfaces blind people can help to localize a specific point in a 3D space. They performed with precision but slower than sighted people concluding that navigating virtual environments with only sound can be more precise to blind people in comparison to sighted persons.[4]

Another study describes the positive effect of 3D audio-based virtual environments.[9] A study in the same line of research used sensory virtual environments through force feedback joysticks simulating real places such as the school or work place. They probed the hypothesis that by providing appropriate spatial information through compensatory channels the performance of blind people can be improved.[10]

A research project in the same direction of[2] concluded that a traditional computer game, Space Invader, can be replicated with 3D sound. Researchers used force feedback joysticks as input interface by letting to play blind to sighted children to share the same experience.[3] An interesting study tested blind and sighted people with covered eyes across audio stimuli by tracing specific places through sound. The skill to hold in mind the specific localization without concurrent perceptual information or spatial update was evaluated.[11]

A trend in the literature is the absence of long-term usability studies on audio-based virtual environments. The literature sustains that spatial audio may have a reduced impact when it is not associated to specific cognitive tasks. There is also a demand for more rigorous and systematic usability studies by and for children with visual disabilities.

Learning the basics of mathematics has been a current issue in literacy literature. Most studies worldwide agree that children do not learn mathematics adequately in the early grades. This has a tremendous impact on further learning. In a world heavily based on science and technology children without understanding the basics of math limit their role in the society. Children with visual disabilities are not the exception. Actually in many respects this issue is radicalized in these children. When blindness is associated to social deprivation the issue of learning primary school mathematics is really a critical issue.[12-14] Thus one of the greatest challenges for children with visual disabilities has been the access and learning of mathematics information.[13] Early learning and practice may project a better construction of mathematics knowledge in visually impaired children.[12]

In this study we intended to foster learning and practice of mathematical concepts such as positional value, sequences, additive decomposition, addition, sum, subtraction, multiplication, and division. Theo & Seth was developed to enhance mathematics learning such as the concept of number and basic operations. AudioMath is used to assist learners with visual disabilities in learning concepts such as establishing correspondence and equivalency relationships, memory development, and differentiating tempo-spatial notions.

DESIGNS

Models. AudioMath has different components. *Specific content* models the representation problem to generate a grid with a pair of related tokens between them to be solved by the child. *Random card generator* is the editor that allows setting the level of complexity and contents from a gallery. *Computer model* is the representation of the real problem. It includes state system variables such as number of correct token pairs, time, and score as well as parametric variables such as level, content, and user name. *Projection* implies transforming input signals to changes perceived by blind users either audible or tactile. It bridges system and interfaces through bidirectional feedback from and toward the user actions. *Interface* includes input/output interaction devices such as audio, keyboard, mouse, force feedback joystick, and tablets.

The model is based on a matrix with rows and columns. There are four levels of complexity: Level 1 with four tokens (two rows and two columns), level 2 with six tokens (three rows and two columns), level 3 with twelve tokens (three rows and four columns), and level 4 with sixteen tokens (four rows and four columns). Colors are used for children with residual vision.[15] This model meets the minimum standards proposed by[16] for software design, and thus validating AudioMath as an appropriate virtual environment to be used for the learning of children with visual disabilities.

The model of Theo and Seth has two components that define the interaction of the learner with the application. *Virtual Environment*: The composing elements are: *Interface Controls* (in charge of controlling the volume), *help* (a system to orient the user to use the keystrokes in the application), and *activities* (containing the specific contents of mathematics). *Interface:* The elements of I/O interfaces are the keyboard and the audio system. The interface coordinates the user interaction with audio feedback. *Software and hardware Tools*. AudioMath and Theo & Seth were developed by using Macromedia Director 8.5. In particular, AudioMath was developed with a library of routines for external joystick control, Xtra RavJoystick. A joystick Side-Winder was used in conjunction with Force Feedback, mouse, keyboard, and Wacon tablets.

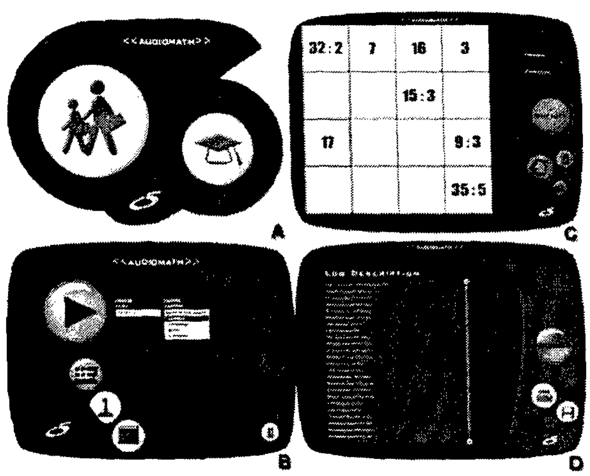


Figure 1. *Interfaces of AudioMath*

Interfaces. The principal interfaces of AudioMath for children with residual vision are displayed in Figure 1. For blind children interfaces are only audio-based. A is the identification screen with two modes: facilitator or student (two buttons). B considers the level of complexity (list box), content (list box), and input device (buttons). Content can be filled, upgraded, and edited by using different media. C is the main interface of AudioMath and includes options such as the position of the card grid, accumulated score, time elapsed (through speech), restart, register, and exit (through buttons). D includes a logging actual use register (buttons) describing each game and movements.

Theo & Seth is game-based and includes interesting mathematics learning activities with different levels of complexity. The metaphor used resembles a grange with two major virtual environments: the kitchen and the henhouse. Two personages interact with the learner and exert actions during the game. The kitchen covers two topics: 1. The henhouse is a virtual space were learners learn how to do sum and rest (figure a), 2. Introduce ordinal numbers and to

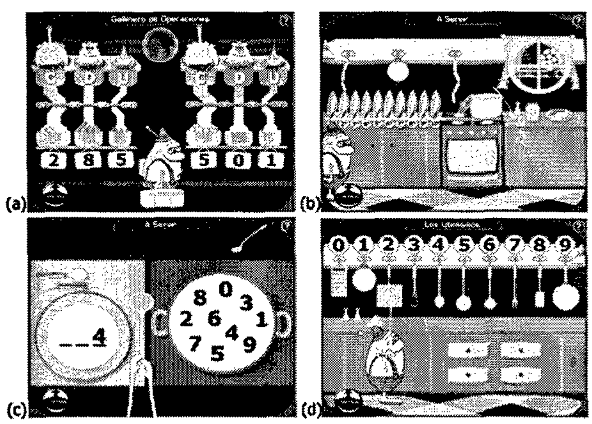


Figure 2. *Interfaces of Theo & Seth*

form soup of numbers (see figure b and c), and 3. Cardinality, including the number, the position in the numerical straight line and information about the antecessor and successor (figure d).

Interaction. AudioMath allows interaction with available interface elements such as buttons and text screens through keyboard. Each interaction triggers an audio feedback and a high visual contrast screen to be perceived by children with residual vision. The child has to move through a grid and open the corresponding token. Each cell has associated music tones that identify the position in the grid. Sound is listened when moving through cells. When open a token the associated element is visible by triggering an audio feedback. For example, if the image is a car, a real traffic car sound is triggered. When open a correct token pair a feedback is set. Finally, when all pairs are made the time used, the final score, and feedback are given.

AudioMath can be interacted through keyboard, joystick, and tablets. A few keystrokes are used with the keyboard. These devices have been used in different applications developed by the research group after testing with children with visual disabilities. The Microsoft SideWinder joysticks in conjunction with Xtra RavJoystick for Macromedia Director allow grading the user position in the grid and give direct feedback with different forces. Counter forces to the movement are generated per each token position change as well as vibratory forces indicate to be near to the grid edge: up, down, left, and right. Force Feedback Joysticks allow direct interaction with diverse degrees of freedom. A plastic graphic grid is posed on the tablet defining the position of each token. A pen is used to point and select interface elements.

During interaction with Theo & Seth children were exposed to cognitive tasks. They had to solve diverse concrete tasks that complement and enrich the experience with the virtual environment. Tasks involved exercises by using simple concrete materials used in everyday life. The way children interact with the software is through keyboard and sound. All the interaction is thought in such a way that children can navigate without assistance. To support this at the very beginning there is a tutorial to learn how to use the keyboard by orienting them about the localization of keystrokes necessary to navigate the virtual world. Once embedded in the environment children can navigate freely and autonomously by interacting with different interfaces.

AudioMath and Theo & Seth emphasize learning concepts such as establishing correspon-

dence and equivalency relationships, memory development, and differentiating tempo-spatial notions. AudioMath were implemented by integrating mathematics content based on the current school curriculum. We embedded the software with mathematical concepts such as positional value, sequences, additive decomposition, multiplication, division, subtraction. We wanted to observe how audio-based virtual environments can foster the construction of mathematics learning in the mind of children with visual disabilities.

METHODOLOGY

Participants. The study with AudioMath was developed with ten children ages 8 to 15 who attend a school for blind children in Santiago, Chile. The sample was conformed of 5 girls and 5 boys. Most of them have also added deficits such as diverse intellectual development: normal, slow normal, border line, below to normal, and with mental deficit. Four special education teachers also participated. All learners met the following prerequisites: to be legally blind, to know the natural numbers, to express sequences orally, to order numbers, to decompose numbers through audio means, to mentally estimate results of additions and subtractions, to mentally determine products and coefficients, to mentally decompose numbers in additions, to manipulate multiplication tables efficiently, and to have notions of fractions.

Theo & Seth was usability tested with nine 7 to 8 years old learners with visual disabilities, four totally blind and five with residual vision. All of them are legally blind. Testing was applied in a school for blind children in Chile. We observed learners responses to both the use of only audio-based virtual environments and the interaction with virtual environments and associated cognitive tasks. Subjects were pre and post tested on mathematics learning.

Evaluation Instruments. Two measurement tests were used to evaluate the impact of AudioMath on learning and practice of mathematical concepts such as positional value, sequences, additive decomposition, multiplication, and division: evaluation of mathematics knowledge test[17] and a usability evaluation test for end-users. The evaluation of mathematics knowledge test measures: The capacity to understand numbers (oral and written), skills necessary to make oral and written calculations, skills to count numeric series and graphic elements, and skills for mathematics reasoning.

Two measurement tests were used to evaluate the impact of Theo & Seth: 1. Precalculus Test (by Neva Milicic and Sandra Schmidt) that evaluates the development of mathematics reasoning in students in early primary school; 2. Mathematics Knowledge Test (Benton and Luria), that evaluates the mathematics knowledge of first grade students. The Mathematics Knowledge Test was adapted to the specific needs of learners with visual disability.

Figure 3-4. *Children solving cognitive tasks with AudioMath and Theo & Seth*

Procedure. Children were tested in the school from July to November 2003, twice a week, and two one hour sessions per week. They followed the steps of pre-testing (evaluation of mathematics knowledge test), interacting with applications, solving cognitive tasks (see Figure 2 and 3), and post-testing (evaluation of mathematics knowledge test). Interacting with AudioMath and solving cognitive tasks were the main steps of the study. During these steps children were observed and assisted by four special education teachers filling check lists and registering observed behaviors. They also applied a usability evaluation test for end-users developed by the authors.

COGNITIVE IMPACT

During the interactive sessions we realized that mathematical content used was appropriate to the educational level of the sample. We analyzed the results case by case because the sample was not homogeneous in key variables such as cognitive deficits and different degrees of blindness.

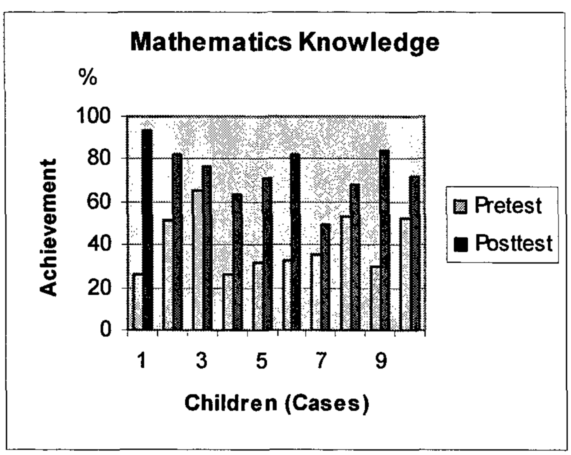


Figure 5. *Pretest-Posttest gains in mathematics knowledge*

Children performed increasingly well in the mathematics knowledge test. An overall view of initial results shows pretest – posttest gains in mathematics knowledge (see Figure 5), thus indicating that interaction with AudioMath associated with cognitive tasks can improve mathematics learning in these children.

In mathematics learning the results were promising. Most evaluated mathematics content was well attained by learners with visual disabilities. The highest gains were in oral calculation (75%) and countdown of numeric series (100%). We believe that these results were also partially due to a better attitude of the children toward work and mathematics knowledge construction such as multiplication tables and use of mathematics operations. They impacted positively on learners by increasing their certainty.

In Theo & Seth the subjects were pre and post tested on mathematics learning. Preliminary results concerning the pre calculus test indicates that children evidence positive changes in mathematics knowledge. Interesting results were obtained when blind children presented an added deficit such as mental development. In these cases the learning of concepts such as cardinality showed important pretest-posttest gains.

Our results indicate that learners with more mathematics learning gains were those that participated by solving associated cognitive tasks. Thus we can conclude that the audio-based virtual environment by itself does not have an isolated impact on mathematics learning. Concrete cognitive learning tasks are powerful supports to the interaction with the audio interfaces. These children have not formal abstract thinking that is somehow embedded in the software. Then concrete tasks are necessary to accompany interaction experiences with audio-based interactive environments.

At the beginning most children did not even know the space distribution of keystrokes in a keyboard. At the end of the experience they used software commands efficiently. A tutorial included may have helped them in this task.

Colors used in the graphical interface such as yellow and blue produced a good contrast for children with residual vision. However the variations types of the same color used did not allow differentiating one element to the other and thus children with low vision got confused.

Audio stimuli such as sound of bird's whispers, personages, tools and devices of the kitchen

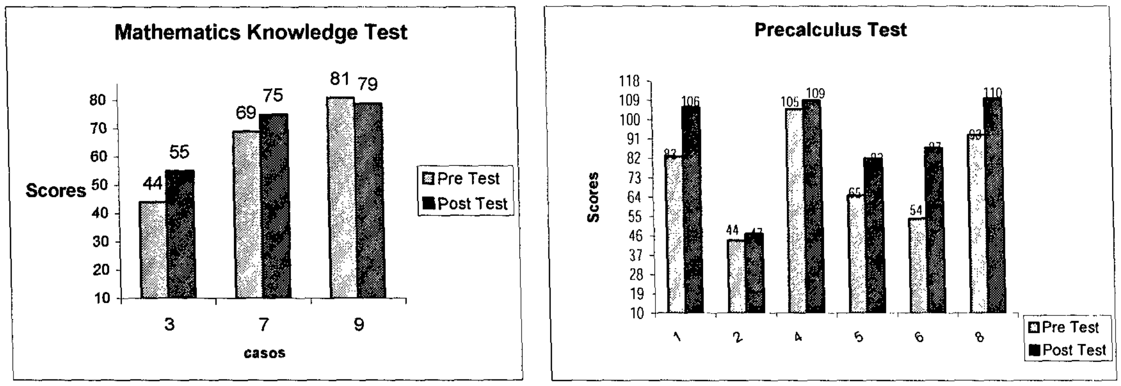


Figure 6-7 *Pretest-Posttest gains in mathematics knowledge*

motivated and help them to interact with the software more actively. We have also found that to attain meaningful learning sound-based environments should be accompanied with cognitive tasks involving written number recognition and reproduction.

Finally, we can conclude that thanks to the interaction with AudioMath and Theo & Seth, and the associated cognitive tasks learners with visual abilities developed mathematics skills. This is a major result in our research because we are initially observing that audio-based virtual environments can foster the construction of mathematics learning in the mind of children with visual disabilities.

DISCUSSION

We have introduced AudioMath and Theo & Seth, virtual environments designed to enhance memory and mathematics skills in children with visual disabilities through audio. The software was made by and for children with visual disabilities. They participated actively in the development of the software. We have also designed interfaces for both blind and children with residual vision. A usability study was implemented with end-users, facilitators, observers, and experts.

AudioMath and Theo & Seth were highly accepted by end-users. They liked, enjoyed, and were motivated when interacted with the software. The flexibility of this application is also a plus. Teachers, children, and parents can include new objects and sounds to adapt them to their needs. Thus, children with visual disabilities can choose sounds to be interacted with and embed them into AudioMath and Theo & Seth. Content can be changed and updated easily. Both virtual environments can be used to support learning primary school mathematics.

The use of concrete materials was also a plus in this study. The children's understanding was easier when they first interacted with concrete materials and then with AudioMath and Theo & Seth. Parallel interaction with both concrete material and AudioMath/Theo & Seth was also an advantage. Once they developed their own mental model of the software the interaction was enriched.

Force Feedback Joysticks introduced a new scenario in virtual environment for blind children. They can provide information and tactile sensations through force feedback. This can help to decrease audio stimuli and relief possible acoustic pollution. Joysticks are devices with a high potential of use due to the availability of many buttons.

Our model fits well the learning of primary school mathematics concepts such as positional value, sequences, additive decomposition, multiplication, and division. Children performed increasingly well in the mathematics knowledge test. Oral calculation and countdown numeric series were highly achieved as well as numeric and associative memory. Concrete cognitive tasks were crucial in this achievement. We firmly conclude that interaction with AudioMath and Theo & Seth associated with

cognitive tasks can help to improve mathematic learning in these children.

More qualitative data are being analyzed. Most of them are case study because each child with visual disabilities is a whole case that deserves a deep analysis to construct meaning about the role that can play audio-based devices in learning general and specific domain skills.

Finally, we are convinced that further research studies we are implementing right now concerning mathematic learning will reaffirm our hypothesis that audio-based virtual environment can foster the construction of mathematics learning in the mind of children with visual disabilities.

Acknowledgements: This report was funded by the Chilean National Fund of Science and Technology, Fondecyt, Project 1030158.

REFERENCES

Baldis, J. (2001). Effects of spatial audio on memory, comprehension, and preference during desktop conferences. In *Proceeding of the ACM CHI 2001*, Seattle, Washington, USA, March 31 – April 5, 2001. Vol 3, 1. pp. 166-173.

Lumbreras, M. and Sánchez, J. (1998). 3D aural interactive hyperstories for blind children. *International Journal of Virtual Reality 4(1. pp.,* 20-28.

McCrindle, R. and Symons, D. (2000). Audio space invaders. In *Proceedings of the Third International Conference on Disability, Virtual Reality and Associated Technologies, ICDVRAT 2000*, Sardinia Italia, 23-25 September, 2000. pp. 59-65.

Mereu, S. and Kazman, R. (1996). Audio enhanced 3D interfaces for visually impaired users. *Proceedings of CHI'96*, ACM Press. (1996).

Sánchez, J. (2000). 3D interactive games for blind children. In *Proceedings of Technology and Persons with Disabilities, CSUN 2000*. Los Angeles, USA.

Sánchez, J. (2001). Interactive virtual acoustic environments for blind children. In *Proceedings of ACM CHI '2001*, pp. 23-25. Seattle, Washington, USA, March 31 – April 5, 2001.

Tan, H. (2000). Haptic interfaces. *Communications of the ACM, 43(3)*. pp. 40-41.

Winberg, F. and Helltrom, S. (2000). The quest for auditory manipulation: the sonified Towers of Hanoi. In *Proceedings of the Third International Conference on Disability, Virtual Reality and Associated Technologies, ICDVRAT 2000*, Sardinia Italia, 23-25 September, 2000. pp. 75-81.

Cooper, M. and Taylor, M. E. (1998). Ambisonic sound in virtual environments and applications for the blind people. In *Proceedings of the Second European Conference on Disability, Virtual Reality, and Associated Technologies, ECDVRAT 1998*, Skövde, Sweden, 10-11 September, 1998. pp. 113-118.

Lahav O. and Mioduser, D. (2000). Multisensory virtual environment for supporting blind persons' acquisition of spatial cognitive mapping, orientation, and mobility skills. In *Proceedings of the Third International Conference on Disability, Virtual Reality and Associated Technologies, ICDVRAT 2000*, Sardinia Italia, 23-25 September, 2000. pp. 53-58.

Loomis, J., Lippa, Y., Klatzky, R. and Golledge, R. (2002). Spatial updating of locations specified by 3-D sound and spatial language. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 28 (2),* pp. 335-345. 2002

Edwards, A. D. N. and Stevens, R. D. (1993). Mathematical representations: Graphs, curves and formulas. In D. Burger and J. C. Sperandio (ed.) *Non-Visual Human-Computer Interactions: Prospects for the visually handicapped*. Paris: John Libbey Eurotext, (1993), pp. 181-194.

Sahyun, S., Gardner, S. and Gardner, C. (1998). Audio and Haptic Access to Math and Science - Audio graphs, Triangle, the MathPlus Toolbox, and the Tiger printer. *Proceedings of the 15th IFIP World Computer Congress*, Vienna, September 1998, pp. 78-86.

Scadden, L. (1996). Making mathematics and science accessible to blind students through technology. *Proceeding of Resna 96 Annual Conference*, (1996), June 7-12, Salt Lake City, Utah, pp. 51-58.

Rigden, C. (1999). The eye of the beholder-designing for colour blind. *British Telecommunications Engineering*, Vol. 17, January.

Sánchez, J., Baloian, N. and Flores, H. (2004). A methodology for developing audio-based interactive environments for learners with visual disabilities, *Proceedings of the World Conference on Educational Multimedia, Hypermedia & Telecommunications, ED-MEDIA 2004*, Lugano, Switzerland, June 21-26.

Chadwick, M. and Fuentes, M. (1980). *Evaluation of Mathematics Knowledge* (adaptation of Benton-Luria test). Santiago, 1980.

Contact

Jaime Sánchez, Ph D.
Department of Computer Science
University of Chile
Blanco Encalada 2120
Santiago, Chile

Virtual War PTSD – a Methodological Thread

P. Gamito[1], J. Pacheco[2], C. Ribeiro[3], C. Pablo[2], T. Saraiva[1]

[1] Psychology Department, University Lusofona de Humanidades e Tecnologias, Lisbon, Portugal
[2] Júlio de Matos Hospital, Lisbon, Portugal.
[3] Military Academy, Lisbon, Portugal.

Abstract: *In vivo exposure is a well-tested and effective treatment for anxious and phobic disorders. However, it is not viable to expose patients with War PTSD to real war environments. As virtual reality exposure (VRE) is currently the most approximate representation of a real war situation, we hypothesized that a treatments of War PTSD that included VRE along with Drug Treatment (DT) would be better than DT alone. The clinical population of this ongoing research consists of male subjects with the diagnostic of War PTSD according to DSM-IV-TR (APA, 2001) who looked for treatment at Hospital Júlio de Matos in Lisbon, Portugal. The patients were distributed into 3 treatments groups (VRE; Drug treatment; VRE+Drug Treatment). The adequate therapeutic dosage of Sertraline (Zoloft, Pfeizer) will be administrated during 16 weeks to the Drug Treatment groups. VRE groups will use a Head Mounted Device that enables fully immersive experience in the following war virtual scenarios: mine deflagration, mine deflagration + ambush, ambush and assisting casualties and waiting for a rescue helicopter. These scenarios were developed using the most up-to-date video game graphics engine. It is also a goal of this study to compare different measurement procedures. In this way, CAPS, BDI, STAI, SCL-90, MCM-II for psychometric measures and TAS, DES, PQ, SUDS, heart rate and blood pressure, ECG, EEG and ACTH for physiological measures are the evaluation procedures selected for assessing the results.*

INTRODUCTION

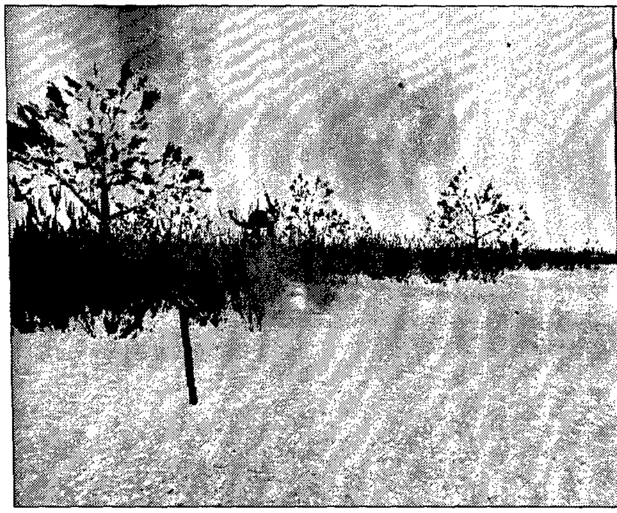
Studies published over the past thirty years show that exposure to phobic stimulus is a fundamental technique in helping patients get beyond difficulties and minimizing the personal, professional and social impact of many anxiety disorders. Virtual reality exposure (VRE) hs been used since 1992 to treat these disorders – especially acrophobia, fear of flying, fear of speaking in public, fear of driving, etc.

Virtual reality exposure (VRE) is more efficient than conventional imagination exposure (IE). For one, subjects can have difficulties in creating or visualizing anxiety-invoking mental images.[1-4] Further, VRE allows for a more real reproduction[1,3-5] and is more immersive than imagination exposure.[4,6,8] VRE induces concentration/attention augmentation to the phobic situation and, during phobic stimulus exposure, diminishes the probability of distraction or cognitive avoidance to the feared situation. In this context, Vincelli[3] states that virtual reality technology produces an experience capable of diminishing the gap between reality and imagination.

Despite having established that VRE may gather some advantages over traditional psychotherapeutic measures (namely, imagination exposure and *in vivo* exposure), studies about the application of VRE in anxiety disorders that generally require the administration of psychopharmacological procedures are lacking.[9] Such is the case with war PTSD. As a disorder with particularly profound effects on patient, his/her family structure and on society as a whole, psychotherapeutic measures are usually not sufficient to ease the distress caused by the memory of war episodes. More often than not, such patients follow a therapy that includes both psychotherapeutic procedures and the administration of psychopharmacological drugs such as sertraline. This is the case of thousands of Portuguese males. Between 1961 and 1974, the Portuguese fought a war on several fronts (Mozambique, Angola and Guine Bis-

sau), the majority of them spending four years on tour in the jungle. Without proper epidemiological studies, authors estimate that 25.000 of them still suffer from war PTSD. As in many cases a composed therapy of drugs and imagination exposure doesn't show significant results. We therefore hypothesized that the exposure to virtual war scenarios in addition to drug treatment would provide a higher reduction on PTSD symptomatology. Rothbaum *et al.*[10,11] studied VRE as an alternative treatment to imagination exposure (IE) in Vietnam war veterans with PTSD, though no matching of VRE with drug treatment was made. The patients were exposed to two virtual scenarios: a) a Huey helicopter flying over a virtual Vietnam field and b) a clearing surrounded by jungle. The authors of said study write that therapists found a reduction of PTSD symptoms in 34% of the subjects and a diminishing of PTSD symptomatology in 45% of them. These gains were maintained throughout 6 months of follow-up. However, results of existent studies show that more research is still needed.

Another goal of the present ongoing research is to define which assessment methodology should be used for monitoring treatment effects. In most of the studies only psycometric measures were used. In fact, Wilhelm & Roth[12]



Picture 1a) Mine deflagration

Picture 1b) Ambush

Picture 2a) Mine deflagration + ambush

Picture 2b) Facing fellow soldiers death/injury situations and waiting for causalities evacuation

stated that psycophysiological methods are not usual to evaluate the responses to a certain aversive stimuli. Nevertheless, it is accepted that self reports are not able to give the complete picture of the reactions and modifications endured by the subject when exposed to the stimuli. We therefore propose that besides psychometric measures like CAPS, BDI, STAI, SCL-90, MCM-II, physiological procedures such as, heart rate and blood pressure, ECG, EEG and ACTH, should be used to assess the exposure results.

METHODOLOGY

VR Model

For the virtualization of traumatic scenes from the war of Portuguese ex-colonies in Africa (Guine Bissau, Angola, Mozambique), the following scenarios were chosen (see picture 1 a), 1 b), 2 a) and 2 b)):

a) Mine deflagration;
b) Ambush;
c) Mine deflagration + Ambush;
d) Facing fellow soldiers death/injury situations and waiting for causalities evacuation.

The scenarios were developed at the Psychology Computing Laboratory of University Lusofona (Lisbon, Portugal) using a Half Life 2 graphic engine. For the immersive exposure a last generation fully immersive Head Mounted Display HiRes 800 PC 3D with an Intertrax Inertia Cube3 (3DOF) will be used.

Clinical Protocol

Procedures

90 selected subjects will be included, in sequential order, in three groups (30 subjects each):

- Virtual Reality Exposure (VRE) Treatment consists in 30 minutes sessions for 14 weeks. Our option was presented by North.[1] The VRE session will be interrupted if a patient feels sick. During the session the patient will be sitting (per suggestion by North *et al*,[1]). The Patient will be instructed that he may not speak about war experiences before beginning the session.
- Drug Treatment (DT)
- Prescription will be executed by a psychiatrist with clinical experience who will indicate the adequate therapeutic dose (initiating with 50 mg/day and after fixating the doses in 100 or 200 mg/day, as required). Sertralina (Zoloft, Pfizer) will be the drug treatment to be administered during 16 weeks.
- Drug Treatment + Virtual Reality Exposure (DT+VRE)
- Same clinical intervention concerning therapeutic relationship, techniques, frequency and duration of therapeutic sessions of VRE and DT will be upheld. The difference consists only on the exposure technique administered.

VRE groups will receive psychoeducational information about anxiety physiology and cognitive-behavioral models of PTSD and anxiety management techniques (diaphragmatic respiration and relaxation) during the two first sessions. Therapist will help the patient modify his dysfunctional thoughts and beliefs through cognitive restructuring.

To be included in DT and DT+VRE groups, all subjects that are taking medication will have to pass a 15 day period of wash-out.

Subjects

Inclusion criteria are male subjects with the diagnostic of War PTSD according to DSM-IV-TR (APA, 2001) who attend a Lisbon central psychiatric hospital (Hospital Julio de Matos). An independent technician will evaluate subjects through a semi-structured clinical interview. Exclusion criteria are cardiovascular disease, epilepsy, substance dependence (in the last year).

After complete description of the study to the subjects, written informed consent will be obtained in accordance with Helsinki Declaration of 1975, as revised in 1983. Patients that accept to participate in the study will be sequentially distributed accordingly experimental groups up to 30 persons for group.

Assessment

There will be a pre-treatment evaluation period and an evaluation at 1, 2, 4, 12 e 24 months.

Pre – 2 – 4 – 6 –12 – 24 months

Evaluating measures are:

PTSD

- CAPS – Clinician-Administered PTSD Scale[13]
  A structured clinical interview that allows for the evaluation 17 symptoms (frequency and intensity) and 8 factors associated with social and professional functioning as well as clinical progress during treatment.
- IES – Impact of Event Scale[14]
  A 15 items self-report questionnaire evaluating experiences of avoidance and intrusion giving current subjective distress related to a specific life event.

Psychopathologic Comorbility

- BDI - Beck Depression Inventory[15]
  A 21 questions survey presented in multiple choice format which purports to measure presence and degree of depression by assessing a specific symptom or attitude "which appear(s) to be specific to depressed patients, and which are consistent with descriptions of the depression contained in the psychiatric literature."[15]
- STAI - State-Trait Anxiety Inventory[16]
  A self-report inventory compose by two subscales developed to measure state and trait anxiety with 20 items each.
- SCL-90 – Symptom-Check-List-90-Revised[17]
  A brief, multidimensional self-report inventory designed to screen for a broad range of psychological problems and symptoms of psychopathology. It is composed by 9 symptom scales – Somatization, Obsessive-Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation and Psychoticism – and 3 global indices - Global Severity Index, Positive Symptom Distress Index and Positive Symptom Total. The SCL-90-R instrument is also useful as a progress or outcomes measurement instrument.

Personality

- MCMI-II – Millon Clinical Multiaxial Inventory-II[18]
  175 true/false items grouped in 10 clinical personality pattern scales, 3 severe personality pathology scales, 6 clinical syndrome scales, 3 modifier indices and 1 validity index. The MCMI-II instrument has been revised to correspond with DSM-IV criteria.

VR reactions

- TAS - Tellegen Absorption Scale[19]
  The most commonly used measure of absorption is the Tellegen Absorption Scale (TAS), a 34 true/false items that evaluate subject involvement capacity on the task or environment. The TAS represents one of 11 primary personality dimensions measured by the Multidimensional Personality Questionnaire (MPQ[19]).
- DES - Dissociative Experiences Scale[20]
  It's a 28 item scale of self-report evaluating dissociative experiences. It is the only dissociative instrument that has been subject to a number of replication studied by independent investigators (Ross, Norton & Anderson, 1988).
- PQ – Presence Questionnaires[21]
  A subjective questionnaire in which subjects classify their experience to VR concerning control, body sensations, distraction and reality factors in a 7 points Likert scale.
- SUDS – Subjective Units of Discomfort (0-100 – LB – 10 mn – 20 mn)
  This scale measure the degree in which the subject is affected by VR by reporting the anxiety level experienced during the exposition session in regular intervals. Scores range from 0 to 100 (0 – no anxiety; 100 – maximum anxiety/panic attack).
- Verbal and motor behavior records, during the session of VRE[1]
- Motivation and control sensation at the end of the VRE session[1]
- Physiological measures
  Patients will be evaluated according to their medical history and to their records of heart

rate and blood pressure, ECG e EEG and ACTH, Cortisol and Prolactine analysis.

3. FINAL CONSIDERATIONS

The present paper continues the methodological thread of the on-going research on the use of virtual reality exposure (VRE) as a therapeutic procedure on a clinical population of war PTSD veterans. The study population is represented by 90 subjects enrolled in the PTSD department of the Hospital Julio de Matos. It is expected that VRE when associated with a psychopharmacological drug will reduce PTSD symptomatology. Moreover, it is also expected that the application of physiological measures will strengthen the assessment of VRE results.

REFERENCES

1. North, M.M., North, S.M. & Coble, J.R. (1998) - «Virtual Reality therapy: an effective treatment for psychological disorders» in G. Riva (Ed.), Virtual Reality in Neuro-Psycho-Physiology, Ios Press, Amsterdam.
2. Riva, Wiederhold & Molinari, (1998) «The Effects of Immersiveness on Physiology, Virtual Environments in Clinical Psychology and Neuroscience», Ios Press, Amsterdam
3. Vincelli, F. (2001) - «Virtual Reality as a clinical tool: immersion and three-dimensionality in the relationship between patient and therapist. Studies in Health Technology Informatics, 81: 551-553.
4. Vincelli, F. & Riva, G. (2002) - «Virtual Reality: a new tool for panic disorder therapy». Expert Review of Neurotherapeutics 2(3): 89-95
5. Vincelli, F. & Molinari, E. (1998) - «Virtual Reality and imaginative techniques in clinical psychology» *in* G. Riva, B.K. Wiedherhold & E. Molinari (Eds.), *Virtual Environments in Clinical Psychology and Neuroscience,* Ios Press, Amsterdam.
6. Botella, C., Perpiña, C., Baños, R.M. & Garcia-Palacios, A. (1998) - «Virtual Reality therapy: a clinical setting lab» in G. Riva, B.K. Wiedherhold & E. Molinari (Eds.), Virtual Environments in Clinical Psychology and Neuroscience, Ios Press, Amsterdam.
7. Routhbaum, B.O., Hodges, L., Kooper, R., Opdyke, D., Williford, J. & North, M.M. (1995) - «Effectiveness of virtual graded exposure in the treatment of acrophobia», American Journal of Psychiatry, 152: 626-628.
8. Wiederhold, B.K., Davis, R. & Wiederhold, M. D. (1998) - «The effects of immersiveness on physiology» in G. Riva, B.K. Wiedherhold & E. Molinari (Eds.), Virtual Environments in Clinical Psychology and Neuroscience, Ios Press, Amsterdam.
9. Wiederhold, B.K & Wiederhold, M. D (2005) - «Virtual Reality Therapy for Anxiety Disorders: Advances in Evaluation and Treatment». American Psychological Association.
10. Rothbaum B., Hodges, L., Alarcon, R., Ready, D., Shahar, F., Graap, K., Pair, J., Hebert, P., Gotz, D., Wills, B., & Baltzell, D. (1999) -« Virtual reality exposure therapy for PTSD Vietnam veterans: A case study». J. Traumatic Stress 12, 263-271.
11. Rothbaum, B., Hodges, L., Ready, D., Graap, K. & Alarcon, R. (2001) - «Virtual reality exposure therapy for Vietnam veterans with posttraumatic stress disorder». J. of Clinical Psychiatry 62, 617-622.
12. Wilhelm, F.H., Roth, W.T., 2001 -« The somatic symptom paradox in DSMIV anxiety disorders: Suggestions for a clinical focus in psychophysiology». Biological Psychology 57, 105–140.
13. Blake, D, Weathers, F., Nagy, L., Kaloupek, D., Klauminser, G., Charney, D. & Keane, T. (1990) - «Clinician – Administered PTSD Scale (CAPS)», National Center for PTSD, Boston.
14. Zilberg, N.J., Wiess, D.S. & Horowitz, M.J. (1982) - «Impact of Event Scale: a cross-validation study and some empirical evidence supporting a conceptual model of stress response syndromes». Journal of Consulting and Clinical Psychology, 50, 3: 407-414.
15. Beck, A.T., Ward, C.H., Mendelson, M., Mock, J. & Erbaugh,J. (1961) - «An inventory for measuring depression». Archives of General Psychiatry, 4: 561-571.
16. Spielberger, C.D. (1983). Manual for the State-Trait Anxiety Inventory (Form Y-1). Palo Alto, CA: Consulting Psychologists Press.
17. Derogatis, L. (1977) - «SCL-90. Administration, Scoring and Procedures. Manual-I for the R (revised) Version and other instrument for the psychopathology rating scale series. John Hopkins University Scool of Medicine, Chicago.
18. Millon, T. (1987) – Millon Clinical Multiaxial Inventory manual II. Minneapolis: National Computer Systems.
19. Tellegen, A. & Atkinson, G. (1974) -

«Openness to absorbing and self-altering experiences ("absorption"), a trait related to hypnotic susceptibility». Journal of Abnormal Psychology, 83: 268-277.
20. Bernstein, E.M. e Putman, F.W. (1986). «Development, reliability and validity of a dissociation state». Journal of the Nervous System and Mental disease, 178: 448-454.
21. Witmer, B.G. & Singer, M.J. (1998) - «Measuring presence in virtual environments: A Presence questionnaire», Presence, 7:225-240.

Contact

Pedro Gamito, PhD
Universidade Lusofona de Humanidades e Tecnologias
Rua Prof. Barbosa Sueiro, 5 2B
1600 Lisbon Portugal
Tel: +351966057132
Email: pedro.gamito@sapo.pt

Clinical Observations

A Progress Report of Long-Term Robot Assisted Activity at a Health Service Facility for the Aged

K. Wada*[1], T. Shibata*[1,3], T. Saito*[1] K. Sakamoto*[1] and K. Tanie*[2]

*[1]Intelligent Systems Research Institute, National Institute Advance Science and Technology (AIST)
*[2] National Institute Advance Science and Technology (AIST)
*[3]PERESTO, JST

Abstract: *We have proposed Robot-Assisted Therapy and Activity since 1996, and have been developing mental commit robots that provide psychological, physiological, and social effects to human beings through physical interaction[1)9)]. The appearances of these robots look like real animals such as cat and seal. The seal robot, Paro, was developed especially for therapy. We have applied seal robots to therapy of children at pediatric hospitals[4)] and to assisting activity of elderly people at a day service center[5)-7)]. Recently, several research groups have tried robot assisted therapy and activity. Dautenhahn has used mobile robots and robotic dolls for therapy of autistic children[10)]. Besides, robot-assisted activity that uses commercialized animal type robots (such as AIBO[11)], NeCoRo, etc.) has been tried[12)-14)]. For example, Yokoyama used AIBO in a pediatrics ward, and observed the interaction between children and pointed out that the initial stimulus received from AIBO was strong. However, the long term stability was quite weak, compared with living animals[12)]. In this presentation, we will explain the results of the robot-assisted activity for elderly people at a health service facility for the aged for more than one year.*

Method: In order to investigate the effects of seal robots to the elderly people, we evaluated moods of elderly people by face scales[15)] that express person's moods by illustration of person's faces, questionnaires of Geriatric Depression Scales (GDS)[16)]. Seal robots were provided into the health service facility on two days per a week from Aug. 2003.

Results: The results of face scale and GDS showed that feelings and depression of elderly people were improved by interaction with the seal robots, Paro. Regarding a case study, Hanako (pseudonym), aged 89, was sociable and comparatively independent. On the first day of the interaction with Paro, she looked a little nervous of the experiment. However, she soon came to like Paro. She treated Paro like her child or grandchild. Her face scale scores after interaction were always lower than before interaction after the first day. Unfortunately, she was hospitalized during Dec. 10 to 26, 2003. When she met Paro for the first time after leaving hospital, she said to Paro "I was lonely, Paro. I wanted to see you again." Her GDS score then improved. To the present, she has continued to join the activity and willingly interacted with Paro. Caregivers commented that interaction with Paro made the people laugh and become more active. For example, their facial expression changed, softened, and brightened. In addition, Paro encouraged the people to communicate, both with each other and caregivers, by becoming their common topic of conversation. Thus, the general atmosphere became brighter.

Conclusions: We have used seal robots, Paro in RAA for elderly people at a health service facility for the aged since August 2003. The results showed that interaction with Paro improved their moods and depression, and then the effects showed up through more than one year. Consequently, the seal robots, Paro were effective for therapy at health service facilities.

BACKGROUND

Interaction with animals has long been known to be emotionally beneficial to people. The effects of animals on humans have been applied to medical treatment. Especially in the United States, animal-assisted therapy and activities (AAT&AAA) are becoming widely used in hospitals and nursing homes.[1,2] AAT has clear goals set out in therapy programs designed by doctors, nurses or social workers, in cooperation with volunteers. In contrast, AAA refers to patients interacting with animals without particular therapeutic goals, and depends on volunteers. AAT and AAA are expected to have 3 effects:

- Psychological effect (e.g., relaxation, motivation)
- Physiological effect (e.g., improvement of vital signs)
- Social effect (e.g., stimulation of communication among inpatients and caregivers)

However, most hospitals and nursing homes, especially in Japan, do not accept animals, even though they admit the positive effects of AAT and AAA. They are afraid of negative effects of animals on human beings, such as allergy, infection, bites, and scratches.

We have proposed Robot-Assisted Therapy and Activity (RAT and RAA) since 1996, and have been developing mental commit robots that provide psychological, physiological, and social effects to human beings through physical interaction.[3-11] The appearances of these robots look like real animals such as cat and seal. The seal robot, Paro, was developed especially for therapy. We have applied seal robots to therapy of children at pediatric hospitals[6] and to assisting activity of elderly people at a day service center.[7-9] Recently, several research groups have tried robot assisted therapy and activity. Dautenhahn has used mobile robots and robotic dolls for therapy of autistic children.[12] Besides, robot-assisted activity that uses commercialized animal type robots (such as AIBO,[13] NeCoRo, etc.) has been tried.[14-16] For example, Yokoyama used AIBO in a pediatrics ward, and observed the interaction between children and pointed out that the initial stimulus received from AIBO was strong. However, the long term stability was quite weak, compared with living animals.[14]

In this paper, we discuss the application of the seal robots to assist elderly people at a health service facility for the aged, observing their psychological and social effects for more than *one year*. Chapter II describes a seal robot that was used for robot-assisted activity (RAA), and ways of experiments. Chapter III explains the effects of RAA on elderly people. Finally, chapter IV offers conclusions.

METHOD

The robot and its major functions are shown in Fig.1. Its appearance was designed using a baby harp seal as a model, and its surface was covered with pure white fur. A newly-developed plane tactile sensor[11] was inserted between the hard inner skeleton and the fur to create a soft, natural feel and to permit the measurement of human contact with the robot. The robot is equipped with the four primary senses; sight (light sensor), audition (determination of sound source direction and speech recognition), balance and the above-stated tactile sense. Its moving parts are as follows: vertical and horizontal neck movements, front and rear paddle movements and independent movement of each eyelid, which is important for creating facial expressions. The robot operates by using the 3 elements of its internal states, sensory information from its sensors and its own diurnal rhythm (morning, daytime, and night) to carry out various activities during its interaction with people.

INSTRUCTIONS: The faces above range from very happy at the left to very sad at the right.

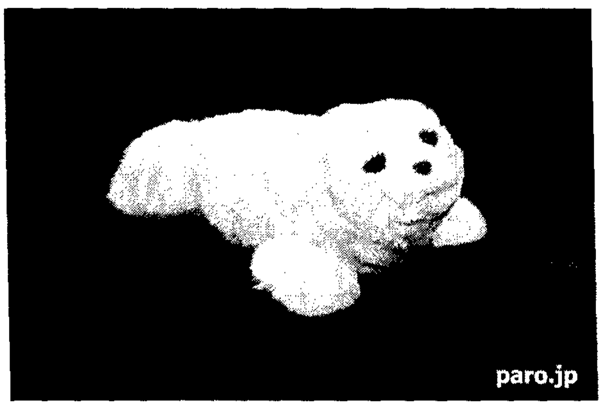


Figure 1. Seal Robot "Paro"

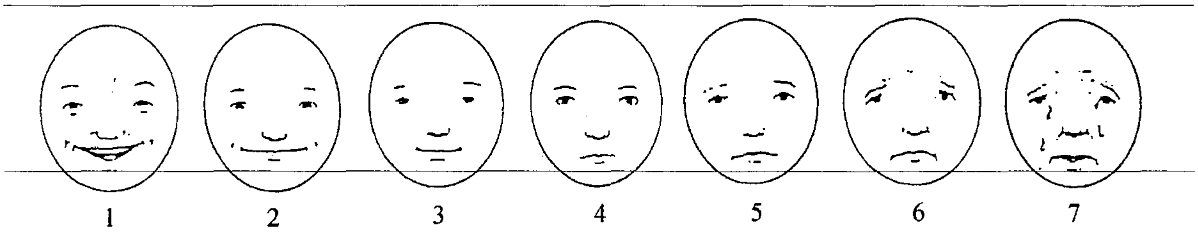


Figure 2. Face Scale

Check the face which best shows the way you have felt inside now.

In order to investigate the effects of seal robots to the elderly people, we evaluated moods of elderly people by face scales[17] that express person's moods by illustration of person's faces, questionnaires of Geriatric Depression Scales (GDS).[18] The original Face Scale contains 20 drawings of a single face, arranged in serial order by rows, with each face depicting a slightly different mood state. However, sometimes subjects are confused by original face scale because it has too many similar images. Then, we simplified it by using seven images #1, 4, 7, 10, 13, 16, and 19 in original ones (Fig.2).

Seal robots were provided into the health service facility on two days per a week from Aug. 2003.

Figure 3. An Elderly Person Kissing the Seal Robot

RESULTS

The elderly interacted with Paro willingly from the first day, speaking to it, stroking and hugging it. Sometimes, they kissed it with smile (Fig.3). Paro became common topics among the elderly people and caregivers (Fig.4). They talked about its appearance, kinds of animals, moods, and so on. For example, "its eyes so big," "it looks sleepy," etc. The elderly people came to love Paro very much and gave them new name "Maru" and "Maro," respectively. After 3 months of the introduction, we added one more Paro to the facility because many other elderly joined in the activity voluntarily. The new Paro was given new name "Hana-chan" by the elderly, soon. Moreover, Paro have been accepted by caregivers widely. They made a home of Paro in the facility.

We obtained the face scale data from 8 subjects (Fig.5). The average scores before interaction varied from 3.3 to 2.0 through 5 months. However, scores after interaction were almost always lower than those before interaction in

Figure 4. Interaction among Elderly People, a Caregiver and a Seal Robot

each week (except Nov. 29). Especially, a statistically significant difference* was shown in Nov. 15 (Wilcoxon's sign rank sum test: p* < 0.05).

Regarding a case study, Hanako (pseudonym), aged 89, was sociable and comparatively independent. On the first day of the interaction with Paro, she looked a little nervous of the experiment. However, she soon came to like Paro. She treated Paro like her child or grandchild. Her face scale scores after interaction were always lower than before interaction after the first day (Fig.6). Unfortunately, she was hospitalized during Dec. 10 to 26, 2003. When she met Paro for the first time after leaving hospital, she said to Paro "I was lonely, Paro. I wanted to see you again." Her GDS score then improved (Fig.7). To the present, she has continued to join the activity and willingly interacted with Paro. Caregivers commented that interaction with Paro made the people laugh and become more active. For example, their facial expression changed, softened, and brightened. In addition, Paro encouraged the people to communicate, both with each other and caregivers, by becoming their common topic of conversation. Thus, the general atmosphere became brighter.

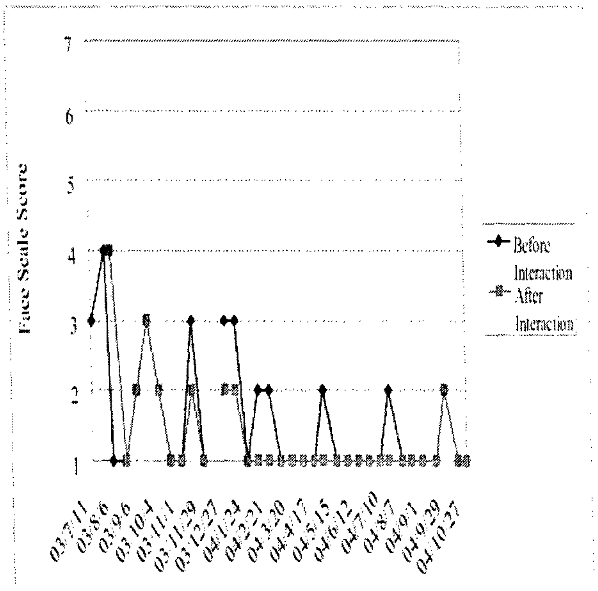


Figure 6. Change of Face Scale Scores of a Subject for 16 months
(Score: 1=best mood, 7=worst mood)

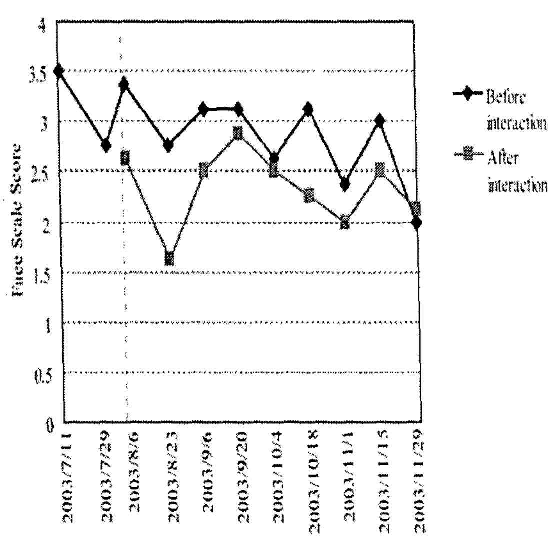


Figure 5. Change of Average Face Scale Scores of 8 Elderly People for 5 Months (Score: 1=best mood, 7=worst mood)

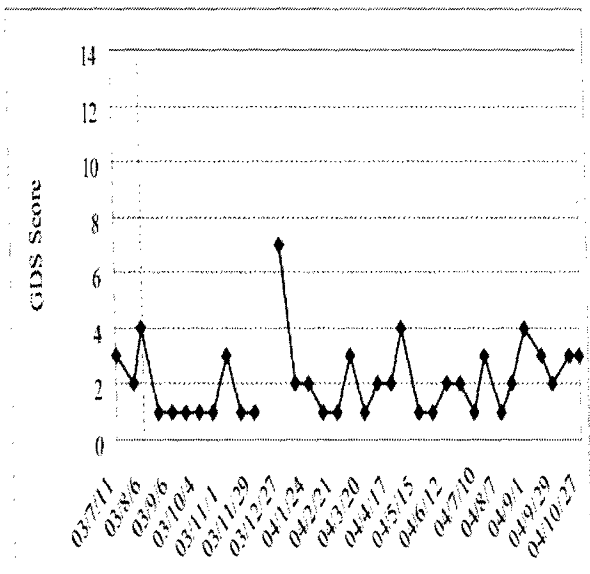


Figure 7. Change of GDS Scores of a Subject for 16 months
(Score: healthy condition <= 5 < probable depression)

CONCLUSIONS

We have used seal robots, Paro in RAA for elderly people at a health service facility for the aged since August 2003. The results showed that interaction with Paro improved their moods and depression, and then the effects showed up through more than one year. Consequently, the seal robots, Paro were effective for therapy at health service facilities.

REFERENCE

M. M. Baum, N. Bergstrom, N. F. Langston, L. Thoma, Physiological Effects of Human/ Companion Animal Bonding, Nursing Research, Vol. 33. No. 3, pp. 126-129 (1984)

J. Gammonley, J. Yates, Pet Projects Animal Assisted Therapy in Nursing Homes, Journal of Gerontological Nursing, Vol.17, No.1, pp. 12-15, 1991.

T. Shibata, et al., Emotional Robot for Intelligent System - Artificial Emotional Creature Project, Proc. of 5th IEEE Int'l Workshop on ROMAN, pp. 466-471 (1996).

T. Shibata, et al., Emergence of Emotional Behavior through Physical Interaction between Human and Robot, Procs. of the 1999 IEEE Int'l Conf. on Robotics and Automation (1999).

T. Shibata, and K. Tanie, Influence of A-Priori Knowledge in Subjective Interpretation and Evaluation by Short-Term Interaction with Mental Commit Robot, Proc. of the IEEE Int'l Conf. On Intelligent Robot and Systems (2000)

T. Shibata, et al., Mental Commit Robot and its Application to Therapy of Children, Proc. of the IEEE/ASME Int'l Conf. on AIM'01 (July. 2001) paper number 182 and 6 pages in CD-ROM Proc.

T. Shibata, et al., Robot Assisted Activity for Senior People at Day Service Center, Proc. of Int'l Conf. on Information Technology in Mechatronics, pp.71-76, (2001).

K. Wada, et al., Effects of Robot Assisted Activity for Elderly People and Nurses at a Day Service Center, Proc. of the IEEE, Vol.92, No.11, pp.1780-1788 (2004).

T. Saito, et al., Examination of Change of Stress Reaction by Urinary Tests of Elderly before and after Introduction of Mental Commit Robot to an Elderly Institution, Proc. of the 7th Int. Symp. on Artificial Life and Robotics Vol.1 pp.316-319 (2002).

T. Shibata, et al., Tabulation and Analysis of Questionnaire Results of Subjective Evaluation of Seal Robot in Japan, U.K., Sweden and Italy, Proc. of the 2004 IEEE Int. Conf. on Robotics and Automation, pp.1387-1392, (2004).

T. Shibata, Ubiquitous Surface Tactile Sensor, 2004 1st IEEE Technical Exhibition Based Conf. on Robotics and Automation Proc. pp. 5, 6, (2004).

I. Werry and K. Dautenhahn, Applying Mobile Robot Technology to the Rehabilitation of Autistic Children, Proc. of 7th Int. Symp. on Intelligent Robotic Systems, pp.265-272 (1999).

M. Fujita and H. Kitano, An Development of an Autonomous Quadruped Robot for Robot Entertainment, Autonomous Robots, Vol.5, pp.7-18 (1998).

A. Yokoyama, The Possibility of the Psychiatric Treatment with a Robot as an Intervention - From the Viewpoint of Animal Therapy-, Proc. of Joint 1st Int'l Conf. on SCIS & ISIS, paper number 23Q1-1, in CD-ROM Proc. (2002).

E. Libin, and A. Libin, Robotherapy: Definition, Assessment, and Case Study, Proc. of the 8th Int. Conf. on Virtual Systems and Multimedia, pp.906-915 (2002).

E. Ohkubo, et. al. Studies on necessary condition of companion robot in the RAA application, Proc. of 2003 IEEE Int. Sympo. on Computational Intelligence in Robot and Automation, pp.101-106 (2003).

C. D. Lorish, R. Maisiak, The Face Scale: A Brief, Nonverbal Method for Assessing Patient Mood, Arthritis and Rheumatism, Vol.29, No.7, pp.906-909, (1986).

J. A. Yesavage, Geriatric Depression Scale, Journal of Psychopharmacology Bulletin, Vol.24, No.4 (1988).

Contact

Kazuyoshi Wada
*1Intelligent Systems Research Institute, National Institute Advance Science and Technology (AIST)
1-1-1 Umezono, Tsukuba,
Ibaraki 305-8568, JAPAN
Tel. +81-29-861-5980
Fax +81-29-861-5992
Email: k-wada@aist.go.jp

Subjective and Physiologic Reactions of Flight Phobics during VR Exposure and Treatment Outcome: What Adds Motion Simulation?

A. Mühlberger, Ph.D.[1], G. Wiedemann, MD[2], Paul Pauli, Ph.D.[3]

[1]Department of Psychology, Biological Psychology, Clinical Psychology, and Psychotherapy, University of Würzburg, Germany
[2] University Hospital of Psychiatry and Psychotherapy, University of Frankfurt, Germany
[3] Department of Psychology, University of Würzburg, Germany

Abstract: Background/problem: *The efficacy of VR exposure for the treatment of fear of flying was confirmed in more than 8 controlled clinical trials. Important goals of future studies are the evaluation of underlying treatment processes and the identification of crucial treatment components, both in order to optimize the treatment. The present study was designed to examine the effect of motion simulation on subjective and physiological fear reactions as part of a VR exposure that also included visual and acoustic stimuli. Our hypotheses were that motion simulation results in stronger initial subjective and physiological fear reactions, and as a consequence is associated with stronger habituations of fear responses within VR flights and between VR flights. Furthermore, we assumed that motion simulation enhances treatment efficacy as measured in the fear of flying scale (FFS).*

Methods and tools: *Twenty fife participants with flight phobia received a virtual reality exposure treatment including written information about fear of flying and how to cope with it (information booklet), one hour of cognitive therapy, and VR exposure (four flights). However, VR exposure included for twelve participants motion simulation while thirteen participants received VR exposure without motion simulation.*

Virtual flights consisted out of a different flying phases (start, flying, turbulences, landing) and were simulated using a head mounted display (HMD), a head tracking device and a motion platform to simulate accelerations and provide proprioceptive stimuli.

Results: *Overall, subjective fear ratings as well as skin conductance responses confirmed substantial fear of both groups during VR exposure. However, these responses were substantially stronger and habituated slower in the VR motion group compared to the VR no-motion group. Nevertheless and in contrast to network theories – which suggest that stronger activation of fear networks should result in an enhanced treatment outcome - we found no differences between groups in treatment outcome. There was even no trend of a superior treatment outcome for the VR-motion compared to the VR-no-motion group.*

Conclusions and novelty: *The present study helps to better understand VR exposure treatment and gives hints for future research to evaluate the treatment process. Based on our results it may be speculated that treatment outcome is more related to the amount of habituation during exposure than to the strength of the initial fear response.*

ACKNOWLEDGEMENTS

Research was supported by the Deutsche Akademie für Flugmedizin (German Academy for Flight Medicine) with a grant to Drs. Pauli and Wiedemann and by the German Research Foundation (DFG) with a stipend to Dr. A. Mühlberger. The study was part of the dissertation of Dr. A. Mühlberger.

INTRODUCTION

Many studies confirm the efficacy of Virtual Reality (VR) exposure for the treatment of different psychiatric disorders, especially for specific phobia.[1,2,3] The efficacy of VR exposure for the treatment of fear of flying was confirmed in more than 8 controlled clinical trials.[4-7]

Important goals of future studies are the evaluation of underlying treatment processes and the identification of crucial treatment components, both in order to optimize the treatment. VR exposure is an especially valuable tool to achieve this since it allows on the one hand to control exposure settings and on the other hand to create a wide range of experimental manipulations.

For exposure therapy, a widely accepted theoretical assumption is that the fear network has to be activated before it can be changed. Foa and Kozak[9] further assumed that this activation has to be reflected in initial subjective as well as physiological fear responses. Following this initial activation, an effective exposure treatment should lead to a habituation of activation both within and between repeated exposures.[9] In line with this assumption, an association between strong initial heart rate reactions during exposure and superior treatment outcome was repeatedly found.[10]

Network theories also predict that effective VR treatments must be able to induce substantial fear reactions. In flight phobics, such substantial fear reactions have been observed in VRs incorporating visual, acoustic and motion simulation[4] or visual, acoustic and vibration simulation.[10] Variables that were discussed to moderate the amount of fear elicited by VR exposure are the presence in VR[11,12] or the feedback of physiological activation during VR.[7] An additional important variable modulating subjective and physiological fear reactions within VR exposure might be the applied simulation modalities.

The present study was designed to examine the effect of motion simulation on subjective and physiological fear reactions as part of a VR exposure that also included visual and acoustic stimuli. We considered this important since motion simulation, on the one hand, might be important to trigger fear during virtual flights but, on the other hand, is rather expensive to add because it needs additional hardware (motion chair). Our hypotheses were that motion simulation results in stronger initial subjective and physiological fear reactions, and as a consequence is associated with stronger habituations of fear responses within VR flights and between VR flights. Based on earlier results[4] we specifically expected heart rate to habituate mostly between flights and skin conductance levels to habituate especially strong within flights. Furthermore, we assumed that motion simulation enhances treatment efficacy as measured in the fear of flying scale (FFS).

METHOD

Participants

Participants were recruited through newspaper articles. Respondents completed a mailed questionnaire package that included a sociodemographic and a medical history questionnaire, and several psychometric instruments which assessed fear of flying, trait anxiety, and psychopathology. For a detailed description of the selection procedure, the inclusion and exclusion criteria, the complete treatment program and characteristics of the participants see Mühlberger et al.[13] Written informed consent was obtained from all study participants.
The presented analyses are based on 25 participants with fear of flying with complete process data: All participants received all treatment components including written information about fear of flying and how to cope with it (information booklet), one hour of cognitive therapy (CT), and VR exposure (four flights). However, VR exposure included for twelve participants motion simulation (VR-motion group) while thirteen participants (VR-no-motion group) received VR exposure *without* motion simulation. For the presented evaluation of treatment outcome missing follow-up data of two participants of the no-motion group was completed by the group mean of all participants who did not fly during follow-up period.

Apparatus

Virtual Reality (VR): The VR environment included visual, acoustic, and partly motion simulations of a commercial flight. VR flights lasted 18 min and included all important flight phases (i.e., take-off, ascending, reaching flight altitude, two phases of air turbulence, descending, and landing).

The visual cues were presented by a head-mounted display (HMD; *V6*, Virtual Research Corporation). The head position was monitored with an electro-magnetic tracking device (*Fast Track*, Polhemus Corporation) in order to adapt the field of view to head movements. A Reality Engine II Computer (Silicon Graphics Corporation) with two processing units provided real-time texture mapping and implemented the real-time rendering of the environment with respect to the head position. A high amount of details and a frame-rate of at least 12 frames per second were achieved by renouncing stereoscopic rendering.

The three-dimensional environment consisted of the inside of an airplane (Boeing 737) and the view through an airplane window (somewhat enlarged compared to reality). The participant's position was a passenger compartment at the left window row in the middle of the plane. The seat at the right of the participant was taken by a virtual passenger. The participant was able to look out of the plane through the window to the left. The outside environment changed dependent on the flight phase (e. g., parking position, runway, airport-tower, several airport-buildings at take-off or landing, fields or clouds while flying).

Sounds were presented by an Indigo Computer (Silicon Graphics Corporation) via earphone integrated in the HMD. The audio cues were original airplane sounds and flight announcements, both recorded and stored as digital audio files.

A motion base with 6 degrees of freedom (Symtech Corporation) was used to manipulate the body position and to simulate motions. Simulations of speed accelerations, speed deceleration (during take-off or landing), and air turbulence (during the flight) were implemented. The motion data mirrored a flight that was performed by a real pilot in a professional flight simulator. A special program ("Wash-out") developed by the Fraunhofer-Institute for Graphical Data Processing (IGD) in Darmstadt was used to transform the data for motion base use and to ensure an optimal and realistic perception of speed acceleration or speed deceleration.

Relevant psychometric measures (for a complete list see Mühlberger et al., 2003).

Subjective Units of Discomfort (SUDs)[14] ranging from 0 (no discomfort) to 100 (panic-like discomfort) were used to assess fear responses. Participants were trained to use this scale, and ratings were requested at eight assessment points per flight (before the start, directly after the start, during quite flight, during two phases of turbulences, once again during quite flight, after landing and reaching the final parking position) via earphone instruction.

The Fear of Flying Scale (FFS[15]) consists of 21 items describing situations representative for air travel (e.g., "The plane accelerates down the runway and lifts off the ground"). The fear elicited by the described situations has to be rated on 5-point scales (not a all (0) to very much (4)). A mean score was calculated. Cronbach's a and 3 month retest reliability of the original FFS were .94 and .86, respectively.[15] We confirmed these indices for our German translation in two studies:[13] Cronbach's a were .90 (N=120) and .98 (N=257); 3 month retest reliabilities were .83 (N= 37) and .87 (N=43).

PROCEDURE

For the evaluation of treatment outcome participants completed the FFS before and after the VR exposure treatment and 6 month later. For a detailed description of the complete treatment and the details of the outcome assessment see Mühlberger et al.[13]

Participants of both VR groups were accompanied to the VR simulator after the same cognitive preparation. The VR devices were then explained. Participants sat down on a cushioned seat mounted on a motion platform and the HMD was put on. Before starting the VR flights, participants were instructed not to suppress their fear during the VR flights, but to experience the fear and its reduction with ongoing exposure. Participants completed four successive VR flights of 18 min duration each; the VR-motion group with motion (including vibration) simulation, the VR-non-motion group without motion (and without vibration) simulation. A break of 5 to 10 minutes separated the second from the third flight.

Physiological data acquisition and data reduction

Electrocardiogram (ECG) and skin conductance level (SCL) were registered continuously with a sampling rate of 384 Hz with a Vitaport I system (Becker Inc.). Skin conductance was recorded from two electrodes placed on the medial phalanges of the second and third finger of the non-dominant hand. The ECG was converted online to heart rate (HR) by an integrated R-wave detection algorithm. Phases of 60 s duration corresponding to SUD ratings were extracted and means for each phase and each flight were calculated. Then, differences to the pre-flights baseline measures were computed. Physiological signals were pre-analyzed offline with the BrainVision Analyser Software of BrainProducts Inc.

Statistical data analysis

SUD, HR and skin conductance were analyzed with mixed ANOVAs with the between factor Motion Group (with or without) and the within factors Flight (one to four) and Phase (8 assessment points). Treatment outcome was analyzed with mixed ANOVA with the between factor Motion Group (with or without) and the within factor Time (pre, post, follow-up). If appropriate, Greenhouse-Geisser corrections of degrees of freedom (df) were applied. Significant effects were followed up with specific ANOVAs or planed contrasts.

RESULTS

Treatment process

Fear reports (SUDs): Figure 1 depicts the mean fear reports (SUDs) assessed during the four VR exposure flights separated for the groups with (VR motion) and without motion simulation (VR no-motion). Strongest fear reports were observed during the turbulence phases of the first VR flight with a mean SUD above 40 in the VR motion group. A decrease of fear within VR exposure flights and across repeated VR flights is clearly visible.

The overall analysis revealed significant main effects of Flight ($F_{(3, 69)}$=24.7, p<.001, $\square^{\square}$=0.52), Phase ($F_{(7,161)}$=12.0, p<.001, $\square^{\square}$=0.34), and Motion Group ($F_{(1, 23)}$=5.5, p=.028, $\square^{\square}$=0.19), and a significant Motion Group by Phase ($F_{(7, 161)}$= 4.6, p=.005, $\square^{\square}$=0.17) interaction. Contrasts revealed a significant habituation from flight to flight ($F_{(1,23)}$= 10.1; 32.5; 32.1, p=.004; <.001; <.001, $\square^{\square}$=0.31; 0.59; 0.58). The main effect of Phase can be traced back to enhanced fear during the start ($F_{(1,32)}$ =17.3, p<.001, $\square^{\square}$=0.43) and the first flight phase ($F_{(1,23)}$=17.3, p<.001, $\square^{\square}$= 0.17), and reduced fear after landing ($F_{(1,23)}$=17.4, p<.001, $\square^{\square}$=0.43), compared to the fear before the start of the flight. The motion group displayed overall enhanced fear responses, which were – as the interaction Motion Group by Phase indicated – stronger as the non-motion group responses' during the first flight phase ($F_{(1,23)}$ =5.9, p=.024, $\square^{\square}$=0.20) and both turbulence phases ($F_{(1,23)}$=4.1; p=.055, $\square^{\square}$=0.15; and $F_{(1,23)}$=6.5, p=.018, $\square^{\square}$=0.22).

Heart rate: The analysis returned significant main effects of Flight ($F_{(3, 63)}$=9.2, p=.001, $\square^{\square}$ =0.30) and Phase ($F_{(3, 63)}$=3.3, p=.023, $\square^{\square}$ =0.13), and significant Phase by Motion Group ($F_{(7, 147)}$=4.3, p=.006, $\square^{\square}$=0.17) and Flight by Phase ($F_{(21, 441)}$=6.2, p<.001, $\square^{\square}$=0.23) interactions. Further analyses within groups returned no significant effects for the VR no-motion group. For the VR Motion group, the main effects Flight ($F_{(3, 30)}$=8.9, p=.005, $\square^{\square}$=0.47) and Phase ($F_{(7, 70)}$=5.4, p=.006, $\square^{\square}$=0.35) and the interaction Flight by Phase ($F_{(21, 210)}$=5.1, p<.001, $\square^{\square}$=0.34) were significant. These effects are based on the strong initial heart rate reaction during the start phase of flight one, a smaller one during flight two (see Figure 2), and no further reactions during flight tree and four (not depicted).

Skin conductance level: The analysis yielded a significant main effect of Phase ($F_{(7,154)}$=4.8, p=.007, $\square^{\square}$=0.18) and significant Flight by Motion Group ($F_{(3,66)}$=5.9, p=.005, $\square^{\square}$=0.21) and Phase by Flight by Motion Group ($F_{(21,462)}$=4.5, p=.005, $\square^{\square}$=0.17) interactions. A separate ANOVA for the VR motion group revealed a significant main effect of Flight ($F_{(3,30)}$=5.5, p=.017, $\square^{\square}$=0.36). Contrasts returned significant habituations between the second and the third flight ($F_{(1,10)}$=5.9, p=.035, $\square^{\square}$=0.37) and between the third and the fourth flight ($F_{(1,10)}$

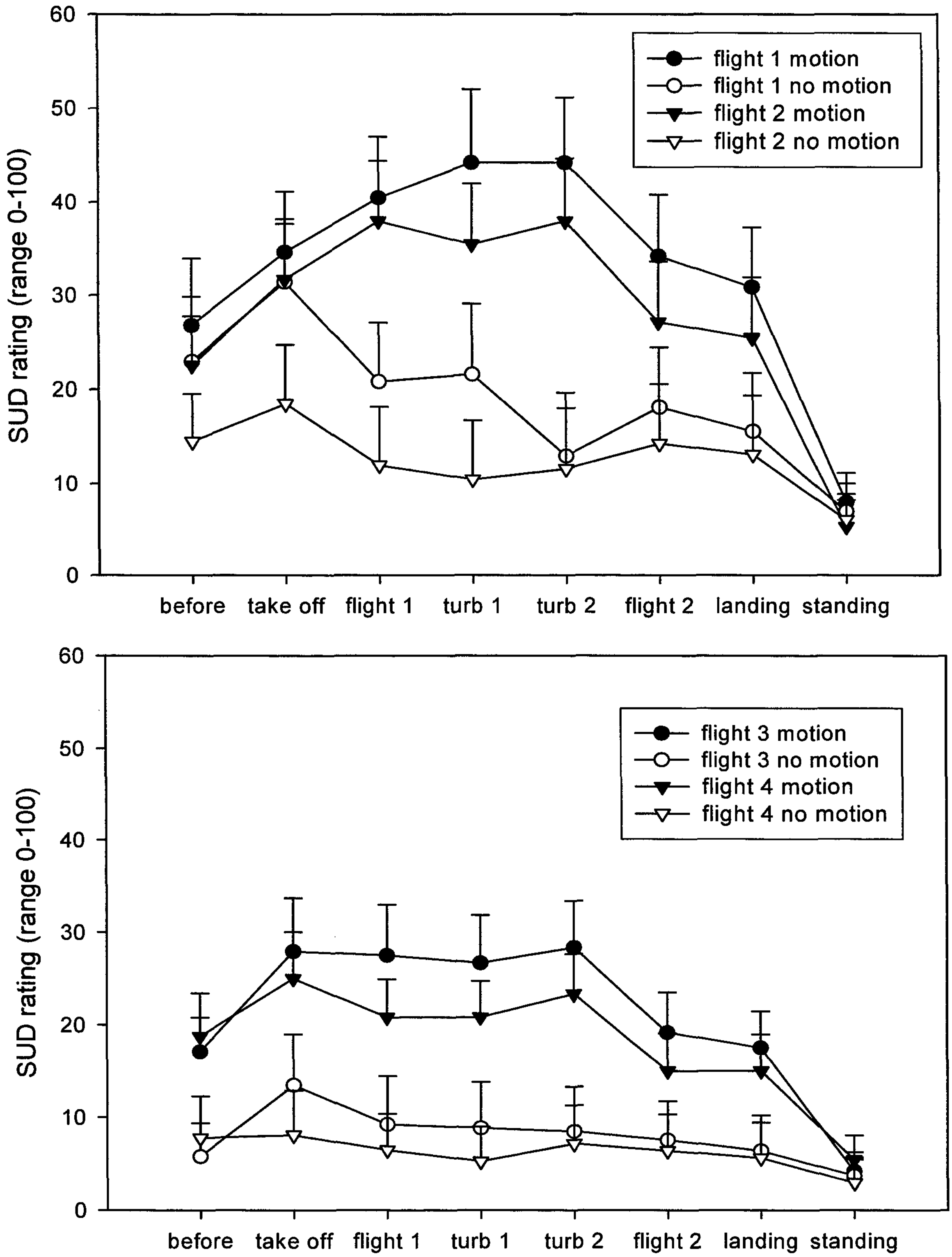


Figure 1. SUD ratings for the first two (top) and the last two (bottom) VR flights of the Motion (N=12) and the No-motion (N=13) groups. Flights have eight phases including two phases with turbulences (turb)

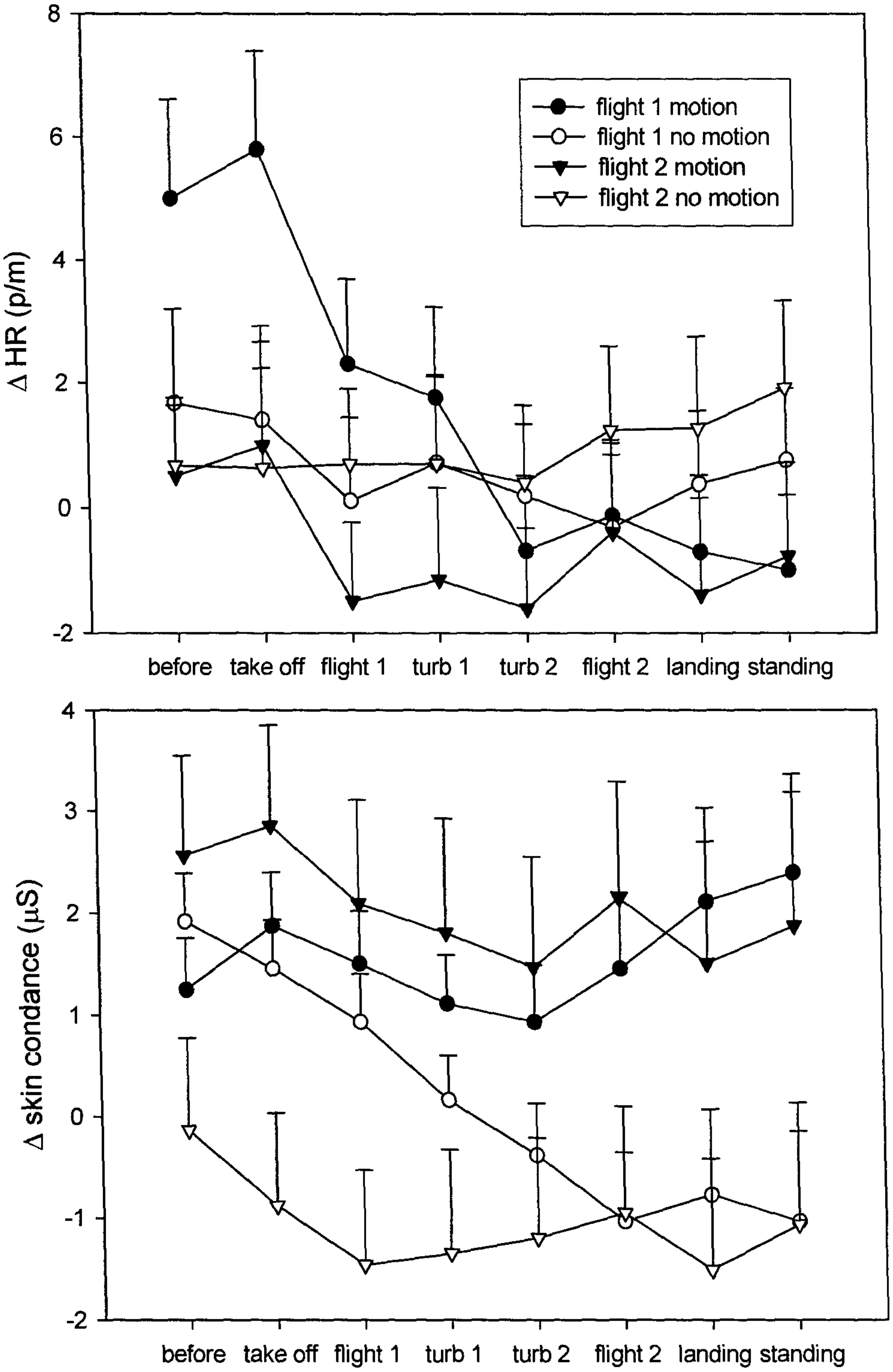


Figure 2. HR responses (top) during the first two VR flights of the Motion and the No-motion groups (N_{motion} =11, $N_{no\ motion}$ = 12) and skin conductance level responses (bottom) during the first two VR flights of the Motion and the No-motion groups N_{motion} =11, $N_{no\ motion}$ = 13); Flights have eight phases including two phases with turbulences (turb).

=8.6, p=.015, η^2=0.46) (not depicted). The ANOVA for the VR no-motion group resulted in a significant main effect of Phase ($F_{(7,84)}$=3.6, p=.041; η^2=0.23) and a significant Phase by Flight ($F_{(21,252)}$=4.0, p=.028; η^2=0.25) interaction. As depicted in Figure 2, skin conductance level of the VR no-motion group habituated strongly during the first flight and remained constant during the second flight.

Treatment outcome (FFS)
Within the VR-motion group, the mean FFS score dropped from 2.7 pre treatment (sd = 0.4) to 1.9 post treatment (sd = 0.4) and 2.1 six months later (sd = 0.7). The corresponding scores for the VR-no-motion group were 2.5 at pre treatment, (sd = 0.5), 1.7 post treatment (sd = 0.8) and 1.7 at follow-up (sd = 0. 9). Significant Time main effects ($F_{(2,46)}$=18.6, p<.001, η^2=0.45) revealed an overall treatment efficacy. The Motion Group by Time interaction was not significant ($F_{(2,46)}$=0.5, p=.489, η^2 =0.02). Contrasts revealed that fear of flying was effectively reduced from pre to post treatment ($F_{(1,23)}$=39.7, p<.001, η^2 =0.63) and from pre-treatment to follow-up ($F_{(1,23)}$=21.6, p<.001, η^2=0.49).

DISCUSSION

Results support prior investigations that found substantial subjective fear reactions of flight phobics during virtual reality (VR) flights. However, the VR with motion simulation induced substantially stronger subjective fear over all flights and all flight phases than the VR without motion simulation. Especially pronounced differences between the motion and the no-motion groups were found during the first flight before and during phases with intensive motion simulation, namely the phases with simulation of air turbulences. SUD ratings decreased immediately after the start phase in the group without motion simulation, while fear remained enhanced in the VR motion group until the phases with turbulences were completed.

Both treatment groups displayed a habituation of subjective fear responses from flight to flight. However, the expected association between strong initial fear reactions and strong habituation effects was not confirmed. Both groups did not differ in the strength of habituation. As a consequence, fear responses at the end of the exposure of the VR-motion group were still higher than the responses of the VR-no-motion group, although both groups had widely diminished subjective fear responses.

Fear associated heart rate responses could only be detected in the VR-motion group. Significant HR accelerations were observed during the first flight's take off phase and – to a weaker extend – during the second flight's take off. During later flights, HR was habituated, and further significant reactions did not occur. The VR group without motion simulation showed no significant HR reactions at all.

Skin conductance level of the VR motion group remained enhanced during the first and second flights and habituated only afterwards. In contrast, the VR no-motion group displayed enhanced SCL responses only during the take off phase of the first flight; SCL responses were habituated during later flight phases and later flights.

Overall, subjective fear ratings as well as skin conductance responses confirmed substantial fear of both groups during VR exposure. However, these responses were substantially stronger and habituated slower in the VR motion group compared to the VR no-motion group. Nevertheless and in contrast to network theories – which suggest that stronger activation of fear networks should result in an enhanced treatment outcome - we found no differences between groups in treatment outcome. There was even no trend of a superior treatment outcome for the VR-motion compared to the VR-no-motion group. Both groups also showed comparable habituation effects, although the habituation within the VR-motion group took place at a higher level (subjective fear) or had a later onset (skin conductance). Although these results are limited due to the small sample sizes, the present study helps to better understand VR exposure treatment and gives hints for future research to evaluate the treatment process. Based on our results it may be speculated that treatment outcome is more related to the amount of habituation during exposure than to the strength of the initial fear response. Furthermore, since activation and

habituation are highly related in exposure therapies,[16] the manipulation of distinct stimuli properties within VR exposure seems to be a valuable tool to clarify the active components of exposure treatments.

REFERENCES

1. Anderson, P., Jacobs, C., & Rothbaum, B.O. (2004). Computer-supported cognitive behavioral treatment of anxiety disorders. *J Clin Psychol*, *60*, 253-67.

2. Krijn, M., Emmelkamp, P.M., Olafsson, R.P., & Biemond, R. (2004b). Virtual reality exposure therapy of anxiety disorders: A review. *Clinical Psychology Review*, *24*, 259-81.

3. Pull, C.B. (2005). Current status of virtual reality exposure therapy in anxiety disorders. *Current Opinion in Psychiatry*, *18*, 7-14.

4. Mühlberger, A., Herrmann, M.J., Wiedemann, G., Ellgring, H., & Pauli, P. (2001). Repeated exposure of flight phobics to flights in virtual reality. *Behaviour Research and Therapy*, *39*, 1033-1050.

5. Mühlberger, A. (2003). Flugangstfragebogen (FFS). In J. Hoyer & J. Margraf (Eds.), *Angstdiagnostik: Grundlagen und Testverfahren* (pp. 431-434). Berlin: Springer.

6. Rothbaum, B.O., Hodges, L., Smith, S., & Lee, J.H. (2000). A controlled study of virtual reality exposure therapy for the fear of flying. *Journal of Consulting and Clinical Psychology*, *68*, 1020-1026.

7. Wiederhold, B.K., & Wiederhold, M.D. (2003). Three-year follow-up for virtual reality exposure for fear of flying. *CyberPsychology & Behavior*, *6*, 441-5.

8. Foa, E.B., & Kozak, M.J. (1986). Emotional processing of fear: exposure to corrective information. *Psychological Bulletin*, *99*, 20-35.

9. Lang, P.J., Cuthbert, B.N., & Bradley, M.M. (1998). Measuring emotion in therapy: imagery, activation, and feeling. *Behavior Therapy*, *29*, 655-674.

10. Wiederhold, B.K., Jang, D.P., Kim, S.I., & Wiederhold, M.D. (2002). Physiological monitoring as an objective tool in virtual reality therapy. *CyberPsychology & Behavior*, *5*, 77-82.

11. Krijn, M., Emmelkamp, P.M., Biemond, R., de Wilde de Ligny, C., Schuemie, M.J., & van der Mast, C.A. (2004a). Treatment of acrophobia in virtual reality: the role of immersion and presence. *Behaviour Research and Therapy*, *42*, 229-39.

12. Regenbrecht, H., Schubert, T., & Friedmann, F. (1998). Measuring the sense of presence and its relation to fear of heights in virtual environments. *International Journal of Human-Computer-Interaction*, *10*, 232-250.

13. Mühlberger, A., Wiedemann, G., & Pauli, P. (2003). Efficacy of a one-session virtual reality exposure treatment for fear of flying. *Psychotherapy Research*, *13*, 323-336.

14. Wolpe, J. (1973). *The Practice of Behavior Therapy.* (2nd ed.). New York: Pergamon Press.

15. Haug, T., Brenne, L., Johnsen, B.H., Berntzen, D., & Götestam, K.-G. (1987). A three-systems analysis of fear of flying: a comparison of a consonant vs a non-consonant treatment method. *Behaviour Research and Therapy*, 25, 187-194.

16. Mühlberger, A., Petrusek, S., Herrmann, M.J., & Pauli, P. (2005). Biocyberpsychologie: Subjektive und physiologische Reaktionen von Flugphobikern und Gesunden bei Exposition mit virtuellen Flügen. *Zeitschrift für Klinische Psychologie und Psychotherapie*, *34*.

Contact

Andreas Mühlberger, Ph.D.
Department of Psychology, Biological Psychology, Clinical Psychology, and Psychotherapy
University of Würzburg
Marcusstr. 9-11
97070 Würzburg, Germany
Tel.: +49 (0)931-312843
Fax: +49 (0)931-312733
E-mail: muehlberger@psychologie.uni-wuerzburg.de

The Virtual Mall: A Functional Virtual Environment for Stroke Rehabilitation

D. Rand M.Sc [1,3], N. Katz Ph.D[2], M. S. MBA[3],
R. Kizony M.Sc [1,2,3] and P. L. Weiss Ph.D[1,3]

[1] Department of Occupational Therapy, University of Haifa,
[2] School of Occupational Therapy, Hadassah-Hebrew University, Jerusalem,
[3] Laboratory for Innovations in Rehabilitation Technology, University of Haifa

Abstract: *Patients who have had a stroke constitute a large population with significant needs for rehabilitation. Even after long, intensive and costly rehabilitation, these patients still suffer from many impairments leading to severe restrictions in participation in every day life. This is a result of limited functional recovery of the upper extremity in addition to cognitive and meta-cognitive deficits. It is also due to insufficient training of IADL functioning during rehabilitation, primarily since such training is both time consuming and technically difficult to implement. The use of VR for rehabilitation of individuals with neurological impairments appears to be promising and its feasibility and effectiveness have been demonstrated in a number of different studies. However, the VR-based interventions that have been developed and reported in the literature used mainly desktop platforms, and the majority of them did not include the stroke population. The aim of this paper is to present the development of a virtual environment using a video capture VR system, which provides an opportunity to carry out therapeutic intervention in a functional, natural and a motivating way. The results of a pilot study on patients with stroke highlighted its many potential advantages. These results as well as future directions will be discussed.*

INTRODUCTION

Stroke is considered to be the third leading cause of death and the most important cause of severe disability in old age.[1,2] Almost half of the patients suffering from stroke retain substantial disability[3] affecting their performance of activities of daily living. The main symptom following stroke is paresis or paralysis to half of the body, contra lateral to the side of brain lesion. Additional symptoms include sensory, perceptual, cognitive and meta-cognitive deficits, which result in a decreased ability to perform activities of daily living.[4] Patients, who demonstrate difficulties functioning in activities of daily living often suffer from deficits in executive functions despite being cognitively intact.[5,6] These patients present problems such as starting and stopping activities, an inability to shift mental processes and behavioral tasks, planning and monitoring deficits as well as keeping a goal in mind throughout a task.[5] The assessment and rehabilitation of executive functions under non-natural conditions such as a research laboratory or clinical facility is still very unsatisfactory, and the evaluation of real life tasks, which has the advantage of giving a more accurate appreciation of the patient's deficits, appears to be time consuming and not suitable for the typical clinical setting.[7]

The functional recovery of the upper extremity after stroke is considered to be exceptional in most cases; the arm does not usually become functional even after intensive and long-standing therapy.[8] Most of patients quickly learn to cope by using only the unaffected arm, and, indeed, prefer to avoid failure by not using the affected arm at all. This phenomenon is known as "learned non-use."[9] Recent research, using "Constraint Induced Movement Therapy" (CIMT) has been shown to be very effective[10] due to the fact that patients use their hands in a functional manner (and not as routine exercises) many times a day (high repetition) which endeavors to stimulate healing process associated with plasticity of the brain.[11]

The objective of rehabilitation is to decrease the various motor, cognitive and meta-cognitive deficits described above, in order to promote the functional ability of basic and instrumental

activities daily living (BADL and IADL). To date, most clinical settings rely on the use of non-functional, routine exercises aimed at decreasing impairment, despite the fact that it would appear to be much more relevant and motivating for patients to exercise while engaged in meaningful, purposeful tasks that are related to real life interests and activities.[12-13] Unfortunately there are limited opportunities for implementing purposeful activities within traditional clinical settings via conventional occupational therapy. Therefore many stroke patients do not return to their premorbid functional level, especially in the more complex instrumental activities of daily living.[14]

Virtual Reality (VR) has the potential to be used as a novel modality in rehabilitation assessment and intervention due to its well known attributes.[15-16] To date, a few studies have examined the use of VR with a stroke population, and in most of these studies very small numbers of patients participated. Kizony et al. assessed the sense of presence and whole body performance in virtual games of patients with stroke.[17] Piron et al used VR to train upper limb reaching movements[18] and Broeren et al. developed a VR haptic device for the assessment and training of motor coordination[19] and Merians et al. used a force feedback glove to improve range of motion, speed and strength of hand movement.[20] Safe street crossing which is a major concern was trained with stroke patients who suffer unilateral neglect using a desktop VR system and found to be useful.[21]

In order to encourage activation of a specific limb, the GX system may be operated while users wear a red glove on one or both hands. If the aim is to improve a user's weak upper extremity, the red glove will be worn only on the impaired hand thereby restricting responses within the virtual environment to that specific body part.[10]

To summarize, VR generally, and the GX VR system especially, appear to have considerable potential for assessing and treating executive functions and the upper extremity motor function of patients with stroke. The importance in developing additional intervention tools that are motivating and challenging for patients with stroke and other neurological disorders who are in need of lengthy rehabilitation and, in particular, opportunities to practice instrumental activities of daily living led us to develop the Virtual Mall using the GX-VR system. The Virtual Mall (VMall) was developed and designed to facilitate assessment and treatment whilst the patient is engaged in a complex, everyday task of shopping. The aims of this paper are (1) to describe the development of a functional virtual environment and it's usability for stroke patients (2) to present the results of a pilot study with eight stroke patients.

DEVELOPMENT OF THE VIRTUAL MALL (VMALL)

The VMall aims to simulate a real shopping mall consisting of different stores in order to provide patients a functional and ecological valid environment which can be used to train motor, cognitive, and metacognitive skills as well as a shopping task itself.

The VMall was developed primarily for use with neurological patients who suffer from motor, cognitive and/or metacognitive deficits. The first population tested was adults and elderly patients who suffer from stroke and whose barriers for independence in daily living were described above. Thus it was important for the VMall to facilitate active movement and executive functions while engaged in the shopping task. In addition, the consideration of rehabilitation principles including flexibility of the environment and the ability to adapt the task to suit the patient's level of ability was also important.

To date, the VMall is a large supermarket consisting of many different aisles. Photographs of real grocery items were taken with a digital camera and rendered via 3-D graphic software. These graphic files were then integrated into the VMall virtual environment. Each aisle is composed of a maximum of 60 products located on shelves, and sorted into different categories such as baking goods, cleaning items, and stationary products. The names of the aisles appear on a sign which also has an image of the type of products located in that aisle (see figure 1, right panel).

The products may be selected and sorted by a therapist thereby providing flexibility with regard

Figure 1: Screen shots of the VMall showing a user selecting a shopping aisle (left panel), a food item (middle panel) and verifying the contents of the shopping cart (right panel).

to the number, type and location of items within each aisle. Four copies of each product, one behind the other, are located on the shelves such that following the purchase of one item, another three may be seen (and purchased). Once all four items are bought, the shelf is bare in that location (see figure 1, middle panel).

The names of each product have been recorded. Thus, in addition to the visual display of the grocery items, the name of the product is heard whenever it is touched. The item is also enlarged when it is touched. This augmented visual and auditory feedback has been added to ensure that the user has correctly identified the desired product.

Several additional features have been included to enhance the user's sense of being present within a supermarket environment. Background "shopping mall" type music is played throughout the shopping experience. Typical announcements of special sales are also heard occasionally during the shopping task. Such announcements may be recorded easily by a therapist and suited to a particular patient or shopping task.

ACTIVATION AND OPERATION OF THE VMALL

The user sees himself within the VMall and the navigation is done virtually touching arrows, which scrolls the screen to the left or right side. Entering the desired aisles is done by touching the sign of the aisle and selecting an item is done by touching it.

At first, the users has to select the desired aisle in accordance with the agreed upon shopping list. Once an aisle is entered, the user faces shelves stocked with different products. The products may be "purchased" by touching them with either hand (provided that a red glove is worn). The selected product then appears in a shopping cart (which may be viewed at any time by linking to a second display screen) (see figure, right panel). Items, acquired by mistake or not needed, may be removed from the cart, by touching them. The user can return from the shopping cart screen to the aisle screen to continue shopping, and from each aisle the user can return to the main screen to choose another aisle. Patients may be given different tasks to do, including, for example, the selection of a specific recipe, compilation of the requisite shopping list (in order to obtain the products needed for that recipe), and the purchase of products from this list.

Output measures include data indicating how well the user accomplished the task (e.g., how many correct items were selected, time to accomplish the task, sequence of items selected, the number of times the user checked his shopping cart) which are recorded and saved automatically thereby providing a record of improvement over time. We are currently investigating the possibility of recording the patient's limb and trunk kinematics while using the VMall.

USABILITY STUDY

Following the initial development of the VMall, six community dwelling individuals with stroke

at a chronic stage were invited to experience the environment. The aim was to test its suitability for the use with stroke patients and to receive user-centered feedback prior to completion of the environment.

Three males and three females, mean age 60.3 ± 9.5 (range 50-74 years), who sustained a right hemispheric stroke 1.5 to 5 years prior to testing, experienced the VMall. They all suffered from varying degrees of weakness in their affected upper extremity but had no cognitive deficits. Five patients were able to walk and one was independently mobile in a wheel chair. Four of them go shopping on a regular basis.

They experienced the VMall for approximately ten minutes while receiving an explanation about how to operate it. They then were given a six item shopping list and were asked to shop for the items. When the task was completed they filled in a feedback questionnaire (the Scenario Feedback Questionnaire (SFQ)[22] with several additional questions related to VMall usability (e.g., To what extent were the products clear?). They were also asked to rate their level of perceived exertion (Borg's scale)[26]. A short interview was done at the end.

Overall the patients all enjoyed their virtual shopping experience very much and said they would very much like to use it again. They all found the task to be challenging and interesting, and commented that it had potential to use in rehabilitation. The mean SFQ scores was 25.6 ± 3.4 points (maximum 30 points) and the mean rated exertion was 13 ± 1.2 points which indicates an easy level. It was interesting to observe that several patients decided to buy items that were not on the list because they needed them at home! Others bought products that were on sale. From these responses we learn that the task appeared to be relevant and realistic for the participants, and that they felt a high level of presence. After using the VMall, one male user remarked: "During the experience ones uses all of his senses, also his imagination and brain." A female user stated "It forced me to straighten my fingers which I never do spontaneously." A second female user commented "It made me feel as I was capable."

During the usability study we encountered a few technical difficulties with the system which have now been resolved. The requisite red glove was difficult to put on the weak hand on some individuals, and it was therefore replaced with a red mitten. One 72 year old patient complained that the products were difficult to identify, and the resolution of the 3D images has now been improved. One female participant said the task was not relevant for her since she never went shopping prior to her stroke, and was not planning to do so in the future. This point is crucial since relevance is a key objective in using the VMall as a therapeutic task. We therefore now include an initial relevancy question prior to usage: "Did you go shopping prior to your stroke?"

PILOT STUDY

Following these improvements, eight additional patients with stroke experienced the VMall. They were all males and their ages ranged from 38-73 years (mean 58.7± 13.3 years). Most of them were during their sub-acute rehabilitation (3-7 months post stroke) whilst one patient was four years post stroke. Five patients had sustained a right hemispheric stroke which caused weakness to their left side of the body and the other two sustained a left hemispheric stroke. All patients used to shop alone or with a spouse prior to the stroke. One patient (44 years old) was a butcher in a supermarket prior to his stroke. They did not have cognitive deficits (the mean Mini Mental State Examination (MMSE) scores ranged from 26-30 points) but all suffered from a different degree of motor impairment of their upper extremity (upper extremity subtest of the Fugl-Meyer Motor assessment (FMA) scores ranged from 7-58 points, mean 35.6 ± 17.5 points).

The protocol was identical except for the interview which was not conducted and extra details of the patient's impairments were collected. This included the MMSE which was used as a cognitive screening test (maximum score 30 points) and FMA (maximum score 60 points) to assess the affected arm's motor impairment.

RESULTS

The SFQ scores ranged from 19-28 points with a mean of 22.6± 3.2 points. For the first ques-

tion "To what extent did you enjoy yourself?" the mean score was 4.1 ± 0.99 points (maximum 5 points). The perceived exertion level was 13.2 ± 3.8 points (which ranged from 8-17 points on Borg's scale) and no side effects were reported. From these results it can be seen that overall these stroke patients who were relatively a short time post stroke with different degrees of motor impairments were able to virtually shop for products using one or both of their hands. They too enjoyed the task and thought it to be relevant for their rehabilitation.

CONCLUSIONS AND FUTURE DIRECTIONS

The VMall seems to have great potential for the use with stroke patients during different rehabilitation stages since it provides an interesting and motivating task which encourages active movement especially of the weak upper extremity and facilitates the use of executive functions. Recently a protocol for intervention of stroke patients who suffer from motor and/or executive functions deficits was developed and a study assessing the treatment efficacy has started. We also plan to use the VMall with different patient's population such as adolescents post stroke and patients suffering from traumatic brain injury.

REFERENCES

Bonita, R. (1992). Epidemiology of stroke. *The lancet, 339*, 342-344.

Duncan, P. (1994). Stroke disability. *Physical Therapy, 74*, 399-407.

Stineman, M.G., & Granger, C.V. (1991). Epidemiology of stroke-related disability and rehabilitation outcome. *Physical Medicine and rehabilitation Clinics of North America, 2*, 457-471.

Pedersen, P.M., Jorgesen, H.S., Nakayama, H., Raaschov, H.O., & Olsen, T.S. (1996). Orientation in the acute and chronic stroke patient: impact on ADL and social activities. The Copenhagen Stroke Study. *Archives Physical Medicine and Rehabilitation., 77,* 336-339

Shallice, T., & Burgess, P.W. (1991a). Deficits in strategy application following frontal lobe damage in man. *Brain, 114*, 727-741.

Fortin, S., Godbout, L., Braun, C.M.J. (2003). Cognitive structure of executive deficits in frontal lesioned head trauma patients performing activities of daily living. *Cortex, 39,* 273-291.

Chevignard, M., Pillon, B., Pradat-Diehl, P., Taillefer, C., Rousseau, S., Le Bras, C., & Dubois, S.B. (2000). An ecological approach to planning dysfunction: script execution. *Cortex, 36*, 649-669.

Brooks, J.G., Lankhorst, G.J., Rumping, K., & Prevo, A.J.H. (1999). The long term outcome of arm function after stroke: results of a follow-up. *Disability and Rehabilitation, 21*, 357-364.

Taub, E. (1980). Somatosensory deafferentation research with monkeys: Implications for rehabilitation medicine. *Implications for Medical Medicine: Clinical applications*. Baltimore, Williams & Wilkins.

Taub, E., Miller, N.E., Novack., T.A., Cook, E.W., Fleming, W.C., Nepomuceno, C.S., Connell, J.S., & Crago, J.E. (1993). Technique to improve chronic motor deficit after stroke. *Archives of Physical Medicine and Rehabilitation, 74,* 347-354.

Liepert, J., Baunder, H., Wolfgang, H.R., Miltner, W.H., Taub, E., & Weiller, C. (2000). Treatment-induced cortical reorganization after stroke in humans. *Stroke, 31*, 1210-1216.

Nelson D.L., & Perterson, C.Q. (1989). Purposeful activity: A theoretic analysis. *Topics in Geriatric Rehabilitation, 4,* 12-22.

Katz, N., Marcus, S., & Weiss, P. (1994). Purposeful activity in physical rehabilitation. *Critical reviews in physical and rehabilitation medicine, 6,* 199-218.

Pettersen, R., Dahl, T., & Wyller, T.B. (2002). Prediction of long term functional outcome after stroke. *Clinical Rehabilitation, 16*, 149-159.

Rizzo, A.A., & Kim (2005). A SWOT analysis of the field of virtual-reality rehabilitation and therapy. *Presence:teleoperators and Virtual Environments,14.*

Riva, G. Rizzo, A., Alpini, D., Barbieri, E., Bertella, L., Davies, R.C., Gamberini, L., Johansson, G., Katz, N., Marchi, S., Mendozzi, L., Molinari, E., Pugnetti, L., Weiss, P.L. (1999). Virtual environments in the diagnosis, prevention, and intervention of age-related diseases: A review of VR scenarios proposed in the EC VETERAN Project. *CyberPsychology & Behavior, 2,* 577-591.

Kizony, R., Katz, N., Weingarden, H., & Weiss P-L. (2002). Immersion without encumbrance: adapting a virtual reality system for the rehabilitation of individuals with stroke and

spinal cord injury. In P Sharkey, CS Lanyi, P Stanton (Eds); *Proceeding of the 4th International Conference on Disability, Virtual Reality and Associated Technology*, University of Reading: Vresprem, Hungary, pp 55-61.
Piron, L., Cenni, F., Tonin, P., & Dam, M. (2001). Virtual Reality as an assessment tool for arm motor deficits after brain lesions. *Studies Health Technology Information, 81*, 386-392.
Broeren, J., Bjorkdahl, A., Pascher, R., & Rydmark, M. (2002). Virtual reality and haptics as an assessment devise in the postacute phase after stroke. *CyberPsychology and Behavior, 5*, 207-211.
Merians, A., Jack, D., Boian, R., Tremaine, M., Burdea, G.C., Adamovich, S.V., Recce, M. & Poizner, H. (2002). Virtual reality- augmented rehabilitation for patients following stroke. *Phys. Ther. 82*, 898-915.
Weiss, P.L., Naveh, Y., & Katz, N. (2003). Design and testing of a virtual environment to train CVA patients with unilateral spatial neglect to cross a street safely. *Occupational Therapy International, 10*, 39-55.
Kizony, R., Katz, N., & Weiss, P.L. (2003). Adapting an immersive virtual reality system for rehabilitation. *J.Visual. Comp. Anim. 14*, 261-268.
www.irexonline.com
Sveistrup, H., McComas, J., Thornton, M., Marshal, S., Finestone, H., McCormick, A., Babulic, K., & Mayhew, A. (2003) Experimental studies of virtual reality-delivered compared to conventional exercise programs for rehabilitation. *CyberPsychology & Behavior*, 6:245–249.
Weiss, P.L., Rand, D., Katz, N and Kizony, K. (2004).Video capture virtual reality as a flexible and effective rehabilitation tool. *Journal of Neuroengineering and Rehabilitation, 1*, 12.
Borg, G. (1990). Psychophysical scaling with applications in physical work and the perception of exertion. *Scandinavian Journal of Work Health, 16*, 55-58.

Contact

Debbie Rand M.Sc
Department of Occupational Therapy
University of Haifa
Tel.: +972 4 8240473
Fax: +972 4 8249753
Email: drand@univ.haifa.ac.il

The Virtual Reality Mirror: Mental Practice with Augmented Reality for Post-Stroke Rehabilitation

A. Gaggioli[1] ; F. Morganti[1] ; A. Meneghini[2]; M. Alcaniz[3]; J. A. Lozano[3]; J. Montesa[3] ; J. M. Martínez Sáez[3]; R. Walker[4]; I. Lorusso[4]; G. Riva[1].

[1] Applied Technology for Neuro-Psychology Lab, Istituto Auxologico Italiano, Milan, Italy
[2] Azienda Ospedaliera dell'Università di Padova, Unità Operativa di Riabilitazione, Italy
[3] MedICLab, Universidad Politecnica of Valencia, Spain
[4] Telecom Italia Learning Services, Rome, Italy

Abstract *The aim of the project is to apply augmented-reality technology to teach motor skills to patients suffering from stroke. To achieve this goal the project adopts an innovative approach based on the use of so-called "motor imagery." Recent studies in neuroscience have provided converging evidence that "imagining" a motor action involves the same brain areas involved in performing the action. This supports the idea – already exploited by sports trainers – that training with motor imagery (mental practice) could be effective in learning new motor skills or in promoting motor recovery after damage to the central nervous system. Previous clinical studies have shown that the rehabilitation of post-stroke hemiplegic patients can be made more effective by combining physical practice with mental practice. However, for many patients who suffer from damage to the central nervous system, mental simulation of movements can be difficult, even when the relevant neural circuitry has not been injured. Starting from these premises, we have designed and developed an augmented-reality workbench (called "VR Mirror") to help post-stroke hemiplegic patients evoking motor images. First, the movement is acquired by the system from the healthy arm. Second, the movement is being mirrored and displayed so that the patient can observe and see as if the impaired arm is performing the movement. Third, the patient is instructed to rehearse in his/her imagination the movement he/she has just observed. Last, the patient has to perform the movement with the affected arm. In this article, we describe preliminary results of a pilot clinical study, which has evaluated the feasibility of using technology-supported mental simulation as an adjunct in the rehabilitation of the upper limb following stroke. DESIGN: Single-case study. SETTING: Physical Rehabilitation Unit of Padua Teaching Hospital, Padua, Italy. SUBJECTS: A 46-year-old man with stable motor deficit of the upper right limb following stroke. INTERVENTION: The patient underwent a single-case design, with four weeks intervention. The intervention consisted of 3 practice sessions per week at the hospital using the VR-Mirror, in addition to usual therapy (Bobath method). This intervention was followed by 1-month home-rehabilitation program using a portable device. MAIN OUTCOME MEASURES: The patient was evaluated for level of impairment and disability. Pretreatment and posttreatment measures included: the upper-extremity scale of the Fugl-Meyer Assessment of Sensorimotor Impairment and the Action Research Arm Test. RESULTS: The patient showed improvement in upper limb score as measured by the two scales. CONCLUSIONS: The improvement observed in the patient is encouraging and warrants further study.*

INTRODUCTION

Hemiplegia is total paralysis of the arm, leg, and trunk on one side of the body. The paralysis presents as weakness that may be associated with abnormal muscle tone (e.g., rigidity or spasticity). The most common cause is stroke, which occurs when a rupture or blood clot reduces blood flow to a specific area of the brain, killing cells and disrupting the abilities or functions they control. Hemiplegia can be caused by damage to a variety of structures including primary sensorimotor areas, supplementary motor, premotor, and parietal cortices, basal ganglia and/or the thalamus.[1] Traditional rehabilitation after stroke focuses on passive (non-specific) movement or on compensatory training of the non-paretic arm. However, only a small percentage

(5–52%) of patients regain functional recovery of the upper extremity.[2] This observation may be related to the limited effectiveness of current therapy techniques used for improving upper limb function, and the very small percentage of the patient's day actually spent in upper limb intervention.[2] Clinical research has demonstrated that intensive, repetitive practice of active functional tasks shows more positive outcomes for upper limb rehabilitation (Langhorne et al, 1996). It has been suggested that these changes occur by modifying neural reorganization of the cerebral cortex.[3] In particular, there is evidence that the reorganization of the cortex may be stimulated not only by physical practice of the task, but also by mental practice of the task without any accompanying movement.[4]

Mental practice, also called symbolic rehearsal or motor rehearsal, is a training technique in which the subjects repeatedly "rehearse" a motor act in working memory, without producing any overt motor output.[5,6] In recent years, several clinical studies have described the contribution of motor imagery practice for improving upper limb motor function after stroke.[7-11] From a neuropsychological point of view, the benefit of mental practice would be to repetitively activate cerebral and cerebellar sensorimotor structures damaged by a stroke, thereby engaging compensatory networks to promote motor rehabilitation.[4,11] Recent neuroimaging experiments using positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) have shown that imagining a motor act is a cognitive task that engages parts of the executive motor system: in particular the supplementary motor area, premotor area, superior parietal lobule, and cerebellum.[4] Efferent discharges produced during imagery may also activate descending motor pathways. Motor imagery increases spinal reflex excitability at a level only slightly weaker than during movement, and corticospinal excitability is similar during imagery and movement.[12] However, for many patients with damage to the central nervous system, mental simulation of movements can be difficult, even when the relevant neural circuitry has been spared.[13] The goal of this project was thus to develop technology tools to assist patients in creating motor imagery. In the following section, we describe a pilot clinical study, which has evaluated the feasibility of using technology to assist patients in creating motor imagery. The rehabilitation protocol consists of an inpatient and an outpatient phase, combining physical and mental practice. In the inpatient phase, patient was trained in a laboratory setting, using a custom-made augmented-reality workbench (VR-Mirror). At the end of this phase, the patient used a portable display device to guide mental and physical practice at his home.

METHODS

Recruitment

Upon an appeal by the researcher to individuals who had been discharged from the rehabilitation setting, VP was the first volunteer who satisfied inclusion criteria for participation in the pilot experiment. VP was a 46-year-old man hospitalized from early November 2003 until end of February 2004 after an ischemic stroke with right hemiplegia.

Comparison between our observations at initial screening and medical records, discharge summaries, therapist observations, and physiatrist observations suggested that the patient's affected limb function had not improved since the time of discharge from the hospital. Before starting the intervention, VP signed an informed consent statement, in accordance with the guidelines of the institutional ethical review board, outlining his rights as a subject.

Neuropsychological assessment

VP was shown to have normal communication and cognitive skills, as measured by the Folstein *Mini-Mental State Examination*,[14] with his score of 28/30 falling within the normal range. The Mini Mental State Examination is a widely used standardized method by which to grade cognitive mental status. It assesses orientation, attention, immediate and short-term recall, language, and the ability to follow simple verbal and written commands. The patient's ability to image mentally was measured using the *Vividness of Visual Imagery Questionnaire*.[15] In the VVIQ patient is asked to imagine different scenarios and rate the vividness of the images generated. The responses to all the questions can be summed to provide an overall score. VP scored 75/80 on the VVIQ, showing good visual imagery ability. This

result was confirmed by the positive performance on the Shepard-Metzler *Mental Rotation Test*, which measures the ability to mentally rotate three-dimensional objects.[16] The *Vividness of Movement Imagery Questionnaire*[17] (VMIQ) which is extensively used in sports, was used to test VP's ability to imagine prior to his engagement in motor imagery intervention. The VMIQ was constructed specifically to test kinaesthetic imagery ability (the ability to "visualize" and "feel" movement) and contains 24-item scale consisting of movements that the subject is requested to imagine. The questionnaire incorporates a variety of relatively simple upper-extremity, lower-extremity, and whole-body movements. The best attainable score is 120, and the worst obtainable score is 24. VP scored 120 on the VMIQ, showing good movement imagery skills. Further neuropsychological examination excluded motor apraxia, ideomotor apraxia, and ideational apraxia.

Testing of motor abilities

VP was tested 5 times: (1) 2 weeks before the first practice session (baseline assessment); (2) at the beginning of the intervention period; (3) 1,5 weeks after starting MI practice (midterm evaluation); (4) at the end of the intervention period; (5) 1 month after hospital practice termination. Further follow-up evaluations are scheduled 12 and 24 weeks after practice termination. VP was evaluated for level of impairment and disability. Pretreatment and posttreatment measures were the *Fugl-Meyer Assessment of Sensorimotor Impairment* (Fugl-Meyer Scale), and the *Action Research Arm Test* (ARA). The *Fugl-Meyer Scale*[18] has been used extensively as a measure of impairment in studies measuring functional recovery in patients with strokes. Its primary value is the 100-point motor domain, which has received the most extensive evaluation.[19] The specific items in the upper-extremity subsections were derived from the Brunnström stages of poststroke motor recovery. The upper-extremity motor component, which consists of 66 points, was used in this study. The *Action Research Arm* Test[20] is an outcome measure designed specifically for use with patients with strokes. The test is divided into 4 categories (grasp, grip, pinch, and gross movement), with each item graded on a 4-point scale (0=can perform no part of the test, 1=performs test partially, 2=completes test but takes abnormally long time or has great difficulty, 3=performs test normally) and a total possible score of 60.

Intervention

Based on VP's responses to the VMIQ, we determined that he was able to use both kinesthetic and visual forms of imagery equally well. Therefore, internal as well as external imagery scenes were applied in his intervention protocol. The intervention focused on the amelioration of specific impairments and on improving speed and precision. All inpatient practice sessions were conducted by the same medical professionals. The coordinator of the practice session is a physiatrist, specialized in Orthopedics and Traumatology, with over 25 years of clinical experience.

Inpatient phase: the Virtual Reality Mirror

The inpatient intervention consists of one daily session, three days a week, for four consecutive weeks. This time frame was chosen because according to available literature the majority of upper extremity rehabilitation programs last 4 to 6 weeks and because substantial improvement has been demonstrated after 4 weeks of imagery practice.[12] Each therapeutic session included ½ hour of traditional physiotherapy (muscle stretching and Bobath neuro-motor rehabilitation) plus ½ hour of VR-Mirror treatment. The treatment focused on the following motor exercises: 1) flexion/extension of the wrist; 2) prono-supination of the forearm; 3) flexion/extension of the elbow with (assisted) stabilization of the shoulder. The apparatus used by the patients consists of a movement tracking system and a custom-designed visualization workbench that we call the *Virtual Reality Mirror*.[21] The VR mirror displays a 3D electronic image of the movement performed by the patient's healthy limb. This is viewed from an first-person perspective, which is supposed to facilitate the generation of kinesthetic motor imagery.[22] Each practice session with the VR-mirror was composed of four phases.

1. During the *pre-training phase* the patient receives instructions, which explain how the treatment works, encouraging the patient to relax and reducing performance anxiety.

2. In the next, *physical training phase* the therapist shows the patient how to perform the movement with the unaffected arm. When the patient then performs the task, the system tracks his arm and creates a 3D model of the movement.

3. In the next, *imagery training phase*, the patient is asked to create a mental image of the impaired arm performing the movement, as viewed from an internal perspective. When the patient starts to imagine the movement, he presses a button (using her healthy hand), pressing it again when he has finished. This allows the therapist to measure the time he takes to imagine each movement (RT). Basic research has shown that response times for physical and imagined movements are subject to common laws and principles[5]: comparing a patient's RTs, while imagining and physically performing the same movements, allows the therapist to statistically assess the quality of the patient's motor imagery.

4. After the patient has completed the mental rehearsal exercise, he is instructed to watch the display on the VR mirror (*virtual training phase*). The 3D model created earlier is used to generate a mirror image of the movement originally performed by the healthy arm. After watching the reflected limb on the screen, the patient is invited to physically perform the exercise, moving her arm in time with the mirror image (see fig. 1). During execution of the task, the system tracks the movement of the impaired arm, measuring the deviation between the movement the patient performs with the impaired arm and the "ideal" movement, as performed by the healthy arm. Using this measurement, which is performed in real time, the system provides the patient with visual feedback describing his performance on the task.

Home-based rehabilitation exercises

Home-based rehabilitation has the advantage that stroke patients can practice skills and develop compensatory strategies in the environment where they normally live.[23] In this protocol, the equipment provided is a Home Portable Device (a portable display) with multimedia capabilities (see fig, 2). The Home Portable Device displays a sequence of pre-recorded movies, picturing the movement to be trained. After viewing the movies, the patient is instructed to take a first person perspective and to imagine performing the task with the impaired arm. The patient performs this sequence three times a week.

RESULTS

The clinical assessment scores are listed in Table 1. Fugl-Meyer scores notable increased during the 4 weeks of intervention with modest increases during the 1 month follow-up. Action Research Arm Test scores consistently increased during the 4 weeks of intervention. There were 3-point increases during the 1 month follow-up. Moreover, the patient had appreciable increases in grip strength for the affected right limb. Measurements of wrist function revealed increases in range of motion during the first phase of intervention, with no losses in move-

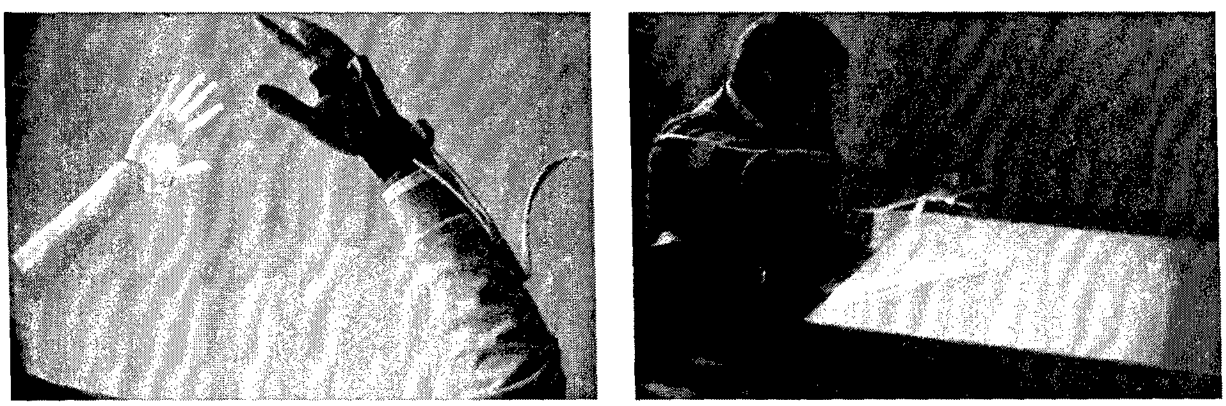


Figure 1. Pictures of the Virtual Reality Mirror in action

Figure 2. The portable display used for the home rehabilitation mental imagery exercises

ment range occurring after the intervention was completed. VP was highly motivated throughout the intervention period and was present at all sessions. From the third week on, he reported on increase in self-confidence using the affected limb.

DISCUSSION

The purpose of this case report was to describe the implementation of technology-supported mental practice for improving motor performance in one individual with hemiplegia of the upper extremity following stroke. We found that mental training combined with physical training improved key measures of sensorimotor impairments and functional ability. Furthermore, these results were maintained (and even improved) at 1 month after home rehabilitation training, suggesting that home practice was useful. A rationale regarding the reason why mental practice with technology combined with physical practice seems to be effective can be found in the motor behaviour and neuropsychology literature. Jackson et al.[4] have recently created a model, comparing the potential therapeutic effects of mental practice with other forms of training. The model assumes that practice involves declarative knowledge, non-conscious processes and physical execution. In their model, declarative knowledge is the explicit knowledge that subjects need before practicing a motor task (i.e., a knowledge of the sequence of movements to be performed); skills that are not directly accessible to verbal description, such as the timing of motor responses to cues or the co-articulation of small segments of movement and the rapid, sequential activation or inhibition of different muscle groups are regulated by non-conscious processes; physical execution is the musculoskeletal activity necessary to carry out the intended action. According to Jackson and his collaborators, these different levels of processing interact in different ways in different forms of training. Physical practice involves all three levels of processing; in mental practice, on the other hand, learning depends crucially on the interaction between declarative knowledge and non-conscious processes: in physical practice it is possible to learn a motor task implicitly; in mental practice subjects have a good declarative knowledge of the different components of the task before they start practicing. The similarity between the circuitry involved in imagining and executing movements suggests, however, that the neuronal network implicated in the non-conscious aspects of a task can be primed as effectively through mental as through physical practice (p. 1138). In addition, the model predicts that internally driven images, promoting kinesthetic "sensations" of movement, could be highly effective in activating the non-conscious processes involved in motor training.

Test	**Baseline**	**Inpatient phase**			**Home rehabilitation phase**
		1 week	Midterm	4 weeks	1 month
Fugl-Meyer (upper limb motricity)	20/66	20/66	27/66	34/66	36/66
Action Research Arm Test	12/60	12/60	20/60	26/60	29/60

Table 1. Functional Improvements After Training

According to Jackson and his colleagues, this would explain why kinesthetic imagery is more effective than purely visual imagery. Their model proposes to conceptualize mental practice with motor imagery as a means to access the otherwise non-conscious learning processes involved in a task. They recognize, however, that the absence of direct feedback from physical execution makes mental practice on its own a less effective training method than physical practice.

In conclusion, results of this pilot study indicate that the stimulation of mental practice through the use of advanced visualization technology, combined with physical practice, leaded to functional gains in the paretic upper extremity of a patient with stable motor deficit of the upper right limb following stroke. Although a single-case study does not allow us to determine precisely the contribute of mental practice and which parameters of the training are most useful, a future goal is to systematically define the most efficacious protocol for each patient. Finally, randomized clinical studies are needed to assess whether this experimental protocol durably improves upper extremity motor function in hemiplegic patients and how these functional motor adaptations are mediated by central neural mechanisms.

ACKNOWLEDGEMENT

The present work was supported by the Commission of the European Communities (CEC), in particular by the IST programme (Project I-Learning, IST 2001-38861) and by the Italian Ministry of University and Research (MIUR) within the project FIRB-NEUROTIV.

REFERENCES

1. Johnson, S. H., G. Sprehn, et al. Intact motor imagery in chronic upper limb hemiplegics: evidence for activity-independent action representations. Journal of Cognitive Neuroscience 2002; 14(6): 841-52.
2. Whitall, J., S. McCombe Waller, et al. Repetitive bilateral arm training with rhythmic auditory cueing improves motor function in chronic hemiparetic stroke. Stroke 2000; 31(10): 2390-5.
3. Traversa R, Cicinelli P, Bassi A, Rossini PM, Bernardi G. Mapping of motor cortical reorganization after stroke. A brain stimulation study with focal magnetic pulses. Stroke 1997; 28(1):110-7.
4. Jackson, P. L., M. F. Lafleur, et al. Potential role of mental practice using motor imagery in neurologic rehabilitation. Arch Phys Medical Rehabilitation 2001; 82(8): 1133-41.
5. Decety, J. and M. Jeannerod Mentally simulated movements in virtual reality: does Fitts's law hold in motor imagery? Behaviour Brain Research 1995; 72(1-2): 127-34.
6. Annett J. Motor imagery: perception or action? Neuropsychologia 1995; 33:1395-417.
7. Crosbie JH, McDonough SM, Gilmore DH, Wiggam MI. The adjunctive role of mental practice in the rehabilitation of the upper limb after hemiplegic stroke: a pilot study. Clinical Rehabilitation 2004; Feb;18(1):60-8.
8. Dijkerman HC, Letswaart M, Johnston M, MacWalter RS. Does motor imagery training improve hand function in chronic stroke patients? A pilot study. Clinical Rehabilitation 2004; Aug;18 (5):538-49.
9. Page, S. J., P. Levine, et al. A randomized efficacy and feasibility study of imagery in acute stroke.
Clinical Rehabilitation 2001; 15(3): 233-40.
10. Stevens, J. A. and M. E. Stoykov. Using motor imagery in the rehabilitation of hemiparesis. Arch
Phys Med Rehabilitation 2003; 84(7): 1090-2.
11. Johnson, S.H. Stimulation through simulation? Motor imagery and functional reorganization in hemiplegic stroke patients. Brain & Cognition 2004; 55(2):328-31.
12. Lacourse MG, Turner JA, Randolph-Orr E, Schandler SL, Cohen MJ. Cerebral and cerebellar
sensorimotor plasticity following motor imagery-based mental practice of a sequential movement. Journal of
Rehabilitation Research Dev. 2004 Jul; 41 (4):505-24.
13. Goldenberg, G The Ability of Patients with Brain Damage to Generate Mental Visual Images.
Brain 1989; 112: 305-325.
14. Folstein MF, Folstein, SE, McHugh PR Mini-Mental State: A practical method for grading the state of patients for the clinician, Journal of Psychiatric Research 1975; 12: 189-198.
15. Marks, D.F. Visual imagery differences in the recall of pictures. British Journal of Psychology 1973;

64,17.
16. Metzler, J. and Shepard, R. N. Mental rotation of three-dimensional objects. Science 1971; 171, 1-32.
17. Isaac, A., Marks, D., Russell, D. An instrument for assessing imagery of movement: The vividness of movement imagery questionnaire (VMIQ). Journal of Mental Imagery 1986; 10, 23-30.
18. Fugl-Meyer AR, Jaasko L, Leyman I, et al. The post-stroke hemiplegic patient, I: a method for
evaluation of physical performance. Scand J Rehabil Med 1975; :13-31.
19. Gladstone DJ, Danells CJ, Black SE. The fugl-meyer assessment of motor recovery after stroke: a
critical review of its measurement properties, Neurorehabil Neural Repair 2002; 16(3):232-40.
20. Lyle RC. A performance test for assessment of upper limb function in physical rehabilitation treatment and research. Int Jouranla Rehabilitation Research 1981; 4:483-492.
21. Gaggioli, A, Morganti, F, Walker, R, Meneghini, A, et al. Training with Computer-Supported
Motor Imagery in Post-Stroke Rehabilitation, Cyberpsychology and Behavior 2004; 7(3), 327-332.
22. Naito E, Kochiyama T, Kitada R, Nakamura S, Matsumura, M, Yonekura Y, Sadato N. Internally
Simulated Movement Sensations during Motor Imagery Activate Cortical Motor Areas and the Cerebellum.
The Journal of Neuroscience, 2002; 22(9):3683-3691.
23. Disler, PB, Wade DT "Should all stroke rehabilitation be home based?" American Journal of Phys Med Rehabilitation 2003; 82(9): 733-5.

Contact

Andrea Gaggioli, Ph.D
Applied Technology for Neuro-Psychology Lab
Istituto Auxologico Italiano, Via Pelizza da Volpedo 41
Milan, Italy
Ph./Fax +39-02-619112892
Email: andrea.gaggioli@auxologico.it

Use, Understanding and Learning in Virtual Environments By Adolescents With Autistic Spectrum Disorders

Sarah Parsons

School of Education, University of Birmingham

Abstract: *There has been increasing interest over recent years in the application of virtual reality technology to facilitating skills and understanding for children with autistic spectrum disorders (ASDs). This paper presents a summary of a series of studies that sought to investigate three main research questions; would adolescents with ASDs be able to: (1) Use Virtual environments (VEs) appropriately? (2) Understand them as representational devices? (3) Learn new information from VEs about social skills? Overall findings suggest that some adolescents with ASDs can use, understand and learn social skills/conventions presented in VEs although some students with lower verbal IQ and weak executive skills benefited less from this kind of intervention. An important consideration for future research is the role of the facilitator in 'scaffolding' participants' use of the VEs. If the aim is to provide effective educational support, to what extent is it useful to try to separate the effect of the VE from the role of a facilitator?*

INTRODUCTION

At the time of writing, even a cursory search on the Internet for "Autism and Virtual Reality" reveals a wealth of hits reflecting the growing interest in the application of advanced technology to the educational realm of children with autistic spectrum disorders (ASDs). According to the National Autistic Society (NAS) in the UK this is part of a trend that has recognised the benefits of computers more generally for people diagnosed with the disorder, which is characterised by severe social and communicative deficits:

> "Because computers offer a context-free environment in which many people with autism feel comfortable, therapists and teachers are increasingly using virtual reality tools to teach life skills, such as crossing the road, and social skills, such as recognising emotions in other people"[15]

However, despite the burgeoning number of Internet hits, there has actually been little in the way of published, peer-reviewed, systematic research investigating the usability and potential of virtual environments (VEs) specifically for people with ASDs. There are good reasons for wanting to know more about this topic though because there are ostensible pros and cons to the approach. On the plus side, there is growing evidence that computer-based educational applications have resulted in significant improvements in the target behaviours or learning objectives for children with autism[4,10,13,22,2] which suggests that virtual reality could be a useful addition to any educational ICT toolkit. Doubts about the usefulness of VR for people with ASDs arise though when considering a particular aspect of the disorder: the difficulty in understanding people's behaviour and intentions in the real world, let alone within the realms of a virtual one[19]. It perhaps seems counterintuitive to facilitate social understanding or communication in the real world by immersing people in a virtual one!

However, the optimism for using VEs with people with ASDs is based on an important premise which is that interactions or experiences in a virtual world may be less threatening for people with ASDs compared to the real world because many of the inputs of real world interaction (which people with ASDs often find very confusing) can be directly controlled or manipulated. This potentially allows a forum where behaviours and responses can be practised and built-upon in a context that shares some similarities with the real world, thereby offering greater potential for generalisation. As the NAS note though, the most important feature of VR is safety: "Above all, VR offers a safe learning environment in which the individual may make

Key	
1	Choose level of difficulty within the VE by pressing corresponding number on keyboard
2	Click to hear overall task
3	Tasks and speech are heard and read simultaneously
4	Click to sit down at the table
5	Icons appear here to pay for items
6	Click to ask a question (or, when a thought bubble appears, find out what another person may be thinking)

Figure 1. Screen shot of café VE illustrating the key functions of the program

mistakes which might be physically or socially hazardous in the real world" [15].

The pioneering work of Strickland[24, 23] provided an initial demonstration that young children with autism could respond appropriately to a virtual scene presented in a head-mounted display. However, the small sample size, coupled with concerns over the acceptability of the heavy headset and lack of any comparison participants meant that the results were limited. Other published articles considered the value of VEs for people with ASDs[6, 25] but (at the time) contained no practical demonstrations of their use. Consequently, there was a clear need to conduct some systematic research to consider fundamental issues about usability and interpretation; in particular, whether people with ASDs could understand a virtual environment as something that *represented* reality; that is, understand important differences between virtual and real worlds but also realise that virtual environments have enough similarities to the real world to usefully inform them about the latter.
In a three-year multidisciplinary research project based at the University of Nottingham, UK (for background information on *AS Interactive* see Beardon et al., 2001; Parsons et al., 2000) we made a start at investigating some of these issues and aimed to answer three main research questions: would adolescents with ASDs be able to (1) use the VEs appropriately? (2) understand the VEs as representational devices? (3) learn new information from VEs about social skills?

The main studies and findings are summarised below, followed by some speculation about the direction of future research in this field.

SUMMARY OF GENERAL METHODOLOGY

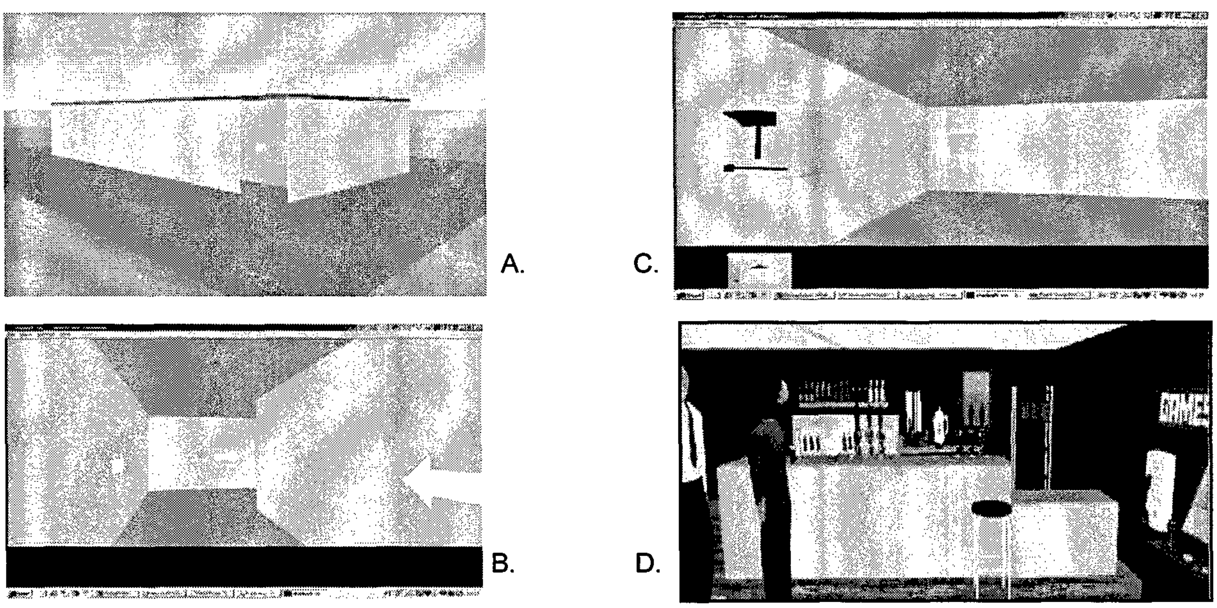
In total, there were two types of VEs – a café and a bus – both of which were presented to participants on a laptop (with a Pentium 3 650MHz Processor, 64 Mb RAM and Windows 98), but could also be used on standard desktop PCs. VEs were navigated with a USB joystick, and objects selected with a standard mouse. Not all studies used both VEs; initially the café environment was used and the bus environment added in later studies. Environ-

ments were built using Superscape Version 5.5 and run using the Superscape Visualiser. The VEs were 'single-user', meaning that only one person could navigate the scene at any one time. The content of the café and bus environments were developed from a series of design iterations[17, 7, 16], so we were confident that the scenarios were easily recognisable and usable for our target participants. Feedback and instructions for users were provided through textual and audible prompts from the programme. There were also a number of functions, represented by icons on the screen, which users could access, such as clicking on a speech-bubble icon to ask a question (see Figure 1).

SUMMARY OF STUDIES AND MAIN FINDINGS

Study 1: The first formal study included a group of adolescents with ASDs, and two non-autistic comparison groups – one matched according to verbal IQ (mean = 69) and the other to non-verbal IQ (mean = 92). Participants were seen individually and used a training VE, which was a single-user environment navigated with a joystick and interacted with via a standard mouse. The training environment consisted of a simple building surrounded by open space (see Figure 2a). Inside the building, there were maze-like corridors (see Figure 2b). Moving around the outside and inside of the building enabled participants to practice manoeuvring in open and confined spaces, respectively. A large room was at the end of the corridor, which contained eight different objects. The objects could be seen only as a green square from a distance, but were revealed automatically as the user moved closer (Figure 2c). Clicking on an object with the mouse moved the item to the black display bar at the bottom of the screen (see Figure 2c in which the kettle has already been selected). There were five training environments in total and participants were required to find a series of four objects in a randomised order, shown on a card visible throughout the procedure (for further details see Parsons, Mitchell & Leonard, 2004).

Over four separate trials, participants with ASDs improved significantly in the time spent completing these tasks, compared to the VIQ-match group, who did not improve significantly. Crucially, by the end of the four trials, the participants with ASDs were not significantly differ-



2 (a) Outside view of the training environment
2 (b) Corridor in the training environment
2 (c) Near and distant views of objects in the training environment
2 (d) Scene from the Virtual Café

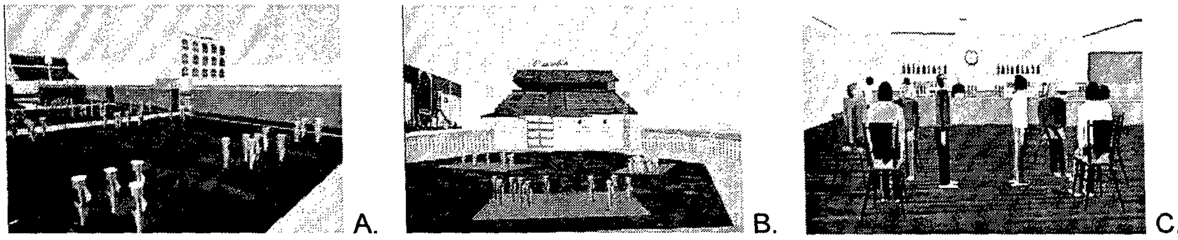


Figure 3(a) starting point; 3(b) approaching the café; 3(c) approaching the counter

ent from the PIQ-match group in time taken to complete the tasks.

In addition, all participants were required to complete a number of tasks in a virtual café (an earlier version to that depicted in Figure 1 taken from Brown et al., 1999), such as find somewhere to sit, order and pay for some food, and move to the counter to order a drink. Participants were also asked to make links, as well as suggest differences, between virtual scenes encountered in the virtual cafe as well as a similar videoed scene including real people in a real bar. A video representation is different from virtual reality in the sense that it is a photo-realistic representation, which is familiar to people through the use of television and other videos. A virtual environment, by contrast, is less familiar to many people and is a more abstract form of representation. Comparing these representations enabled us to see whether participants interpreted them in similar ways. The majority of participants with ASDs understood the VE as something that represented, but was not identical to, reality. That is, they said that virtual people in the scene were talking to each other or to the barman even though they were not actually talking, but were oriented towards each other in such a way that suggested interpersonal interaction. In addition, the majority of participants with ASDs also acknowledged important differences between the VE and the video; that the people in the VE were not real but the people in the video were.

Most participants also completed the tasks in the virtual café successfully, but the groups differed significantly in one important respect. When approaching the counter to buy a drink, the participants with ASDs were judged (by naïve observers) as significantly more likely to move very close to, or walk between a virtual couple stood at the bar, compared to both the VIQ- and PIQ-matched groups. This behavior seems socially inappropriate, especially as there was a large empty space at the bar, to the right of the couple (see Figure 2d).After ruling out a number of explanations, such as weak navigational and executive skills (behaviours involved in sequencing, planning and impulse control), it seemed possible that the participants with ASDs might struggle more than others with understanding the importance of personal space in social situations (at least as depicted in a virtual environment), despite understanding the appropriate representational character of VEs.

Study 2: A second study[21] explored whether participants with ASDs adhered to social conventions generally in VEs, such as avoiding walking across a neighbour's garden and respecting the personal space of people ostensibly engaged in conversation (see Figure 3).

The majority of participants with ASDs behaved in a similar way to non-autistic comparison groups by treating the VE like a game in most situations. That is, they often walked between the two virtual people en route to a counter in a virtual cafe, however members of the ASD group were less likely to remark that this was socially unacceptable than students in the comparison groups. Students with ASDs were also more likely to walk across a neighbour's garden compared to the PIQ-match group, and a third of the ASD group (4 out of 12) showed substantial 'off-task' behaviour. This involved them walking around the café, sometimes even behind the bar, and navigating up to other people in the scene. This behaviour was shown by students with low VIQ and weak executive abilities (as assessed by the Behavioural Assessment of the Dysexecutive Syndrome; BADS[26]), and

only by a subset within the ASD group. People in this subset were also unable/unwilling to comment on the links between the VE and 'real world' behaviour, even when compared to the VIQ-match group. Thus, it is possible that a minority of students with ASDs may struggle especially with understanding how the VE can inform them about reality.

By contrast, many of the comparison participants, but none in the ASD group, reflected on the fact that they would behave differently in real life because it was not socially appropriate to walk through people's gardens, or between people having a conversation, for example:

> 'In real life, I wouldn't go though the middle, but because it's VR you treat it differently – you know it's not real. [I was] just interested in the completion of the task' – PIQ-match student.

Interestingly, although in the minority, some participants who avoided walking between the two people en route to the counter were very sensitive to the social relevance of the virtual café (including some of the ASD students), for example:

> '... if there were two people facing each other, it looked like they were having a conversation. It would not be very good to walk through. If they had their backs to each other it would not make much difference which way I was going' – ASD student.

Thus, some of the participants with ASDs showed a good understanding of particular social conventions in the VE – namely, not walking across neighbours' gardens and not walking between people having a conversation. Nevertheless, these individuals were in the minority within the group – with the remainder unwilling to respond to questions or seemingly unaware of the real world implications of their behaviour. This was in contrast to the VIQ- and PIQ-matched groups, who seemed more willing to use the path/pavement at the start of the task and more aware of how their behaviour in the VE related to real world social conventions. Taken together, the first two studies provided some in-depth information about how a group of adolescents with ASDs use and interpret VEs. In particular, there was evidence to suggest that they were on a par with typically-developing counterparts in their ability to use the VEs, and understood the scenes as appropriately representational. By contrast, the main weaknesses for participants with ASDs seemed to be in the social domain – reinforcing the view that VEs could offer some support in this area by presenting scenes and ideas that were not already well within the grasp of most students with ASDs. Thus, a remaining crucial question was whether participants with ASDs could *learn* specific social conventions using the technology.

Study 3: This was addressed in a third study[12], which included a group of six adolescents with ASDs. Participants used a new version of the virtual café with the learning objectives of finding an appropriate place to sit, and asking appropriate questions (Figure 1). Specifically, the aim was to help students understand that if there is a completely empty table available in a café then it is more appropriate to sit at it than with strangers, but if there are no completely empty tables free then it is appropriate to ask a question before sitting down (e.g.'Is it OK if I sit here?). The virtual café incorporated four different levels of difficulty as the user progressed; the café became increasingly busy and noisy, with fewer choices of appropriate seating. Participants used the VE, with the support of a facilitator (the researcher in this case) over a number of sessions. They were also asked to make judgments about where they would choose to sit, and why, in video clips of real cafes. The video clips, whilst not ideal, served as approximations to judgements about the real world. These were presented to participants for comment before and after VE use and naïve coders were asked to rate the explanations for social appropriateness.

Results showed that four of the six participants improved in their awareness of social conventions, both in terms of performance in the virtual café and in judgments and comments made in relation to the video clips. That is, a majority of participants were judged as providing more socially appropriate and insightful comments about where they would sit and why in relation to the video scenes, specifically following a session with the VE. An example of high-scoring reasoning was: "because no-one's sitting there,

I won't be in anyone's way", and of low-scoring reasoning: "so I can look at the windows".

The design of the study allowed us to pinpoint the improvement in understanding to the specific time of VE use, and not to general improvement in understanding over time. This was because whilst all participants received the same tasks, they were completed in a different order; for example, half the participants had sessions with the VE between the video measures at Time 1 and Time 2, whilst the remainder had their VE sessions between the video measures at Time 2 and Time 3. Gains in understanding should be apparent directly following VE but not necessarily during testing sessions that did not directly follow the VE. Importantly, the facilitator played a crucial role in the success of this approach, by helping the user to interpret, understand and discuss the social scenes depicted in the VE.

Study 4: Finally, after demonstrating successful outcomes in terms of use, understanding and learning in the first three studies, it was important to highlight the views of people with ASDs directly to gain a sense of how they viewed the VEs and whether they thought VEs could be useful to them in any way. Therefore, in the final study we adopted a case study approach with two adolescent males with an ASD and sought their opinions and comments over a number of sessions with the VEs, and during an informal interview[18]. Both students learned the target social conventions (these were the same as the third study) over the period of VE use, with the aid of rich discussions with the facilitator about social aspects of behaviour and what other people (in the virtual scene) could be thinking. In addition, both students commented on how the VE could be relevant to their lives, and one student excitedly remarked how he had used the information he had learned from the VE in a real life situation. He was travelling on a busy train in the summer break and there were few empty seats, so he asked a man if the seat beside him was free. The student said that he felt proud about asking the question because this was not something he would have usually done. In addition, he said how much the VE had helped him "Cause it could help me learn what polite and sensible things to do in public places" (student with ASD, aged 14).

CONCLUSIONS

Whilst anecdotal, comments like the one included above are extremely encouraging and add to our growing body of knowledge about whether, and how, people with ASDs can use, understand and learn from VEs depicting social situations. Overwhelmingly, the emerging picture from the four studies summarised here is a positive one, which can continue to be built upon in any future work. This is especially encouraging in the context of fairly limited functionality in the VE and the rather unconvincing representations of people in the scene, which were blocky and cartoon-like in appearance. Despite such limitations, many of the participants assigned representational qualities to the scene (being *like* reality in some respects but not *identical* to it) and enjoyed using the VEs. An important point to note too is that the VEs and learning objectives were designed with the input of teachers working with the participants and so were based on clearly identified needs. This was an essential part of the project and ensured that the research put the needs of participants first rather than pursuing worthy but perhaps esoteric agendas of the research team! Virtual environments and programming expertise can now accommodate far more sophisticated levels of representation as well as more finely tuned aspects of interpersonal behaviour including direction of gaze and conversation. Recent work from David Moore and his students in the UK, for example, has utilised collaborative virtual environments (CVEs) for investigating the usefulness of emotionally expressive avatars in communicative contexts for children with autism[9] as well as considering aspects of gender, personal space and anxiety, which could eventually be useful for children with autism[14]. The use of CVEs allows great potential for developing social and communicative skills in more dynamic (yet safe) environments than has hitherto been possible, thus offering greater potential for learning skills that are likely to be of use in the real world.

It is an exciting time for researchers because the potential for creating really beneficial outcomes for children with ASDs is a distinct possibility, although of course there is still a great deal to be done in research terms. There is also a need for researchers to be clear about their

aims and why participants with clinical diagnoses (including autism) are involved in studies; it could be too easy to pursue a line of investigation because it seems timely and interesting but ultimately of limited benefit to participants. There are essentially three main potential foci for 'Autism and Virtual Reality' research: what participants with autism can tell us about VR; what VR can tell us about autism and what VR can offer people with autism in terms of educational/learning needs.

In terms of what participants with autism can tell us about VR, there are substantial ethical concerns about including people with clinical disorders in research where the technology rather than the people is the primary focus. For example, the unique perspective that people with ASDs may have on the (real) world could tell us something interesting about the nature of VEs themselves, but is it ethically justifiable to pursue such a question by itself? Similarly, there is a query about what VR stands to tell us about the condition of autism *per se*? Despite substantial research on how non-autistic members of the population use, interpret and understand VEs, the links between virtual and real world behaviours are still not properly understood, including when and why people choose to apply real world conventions to virtual contexts and when they do not. Do we know enough about the use of VEs more generally to draw many conclusions about how or why participants with ASDs might respond in virtual contexts and how that links to real world understanding? Of course, answers to these questions may arise in the context of a project with a more educational focus (and this was certainly the case for the *AS Interactive* project) and would be interesting to know, but I would question using the above two foci as starting points. Instead, they could be questions that are tackled en route to a more outcome focused research approach, which provides something (however imperfect and limited) back to the relevant participant groups.

The main point is that the potential of VEs for providing powerful learning contexts for people who would really benefit from them should be the primary aim and driving force of research in this area. The question of 'what's in it for the participants?' should be at the forefront of researchers' minds as they contemplate how to take this work forward. This may mean adopting research approaches that take into account the importance of context and interaction around the computer when considering whether and how learning takes place. The challenge of this became most apparent for me in discussions about the role of a facilitator in the use of the VEs; that is, someone who sat alongside the participant and guided them verbally through the social situations depicted, perhaps asking the participant to clarify why they took that route or talking through the motive or reasoning for other people behaving in a particular way (see Parsons et al., in press and Mitchell et al., submitted).

Quite clearly, from an experimental research point of view, it becomes impossible to say what was really helping to do the job of learning; was it the 'experiential' nature of the VE and the opportunity to practice the behaviour repeatedly, or the interpretation and 'scaffolding' offered by the facilitator, or a combination of both? I would argue that, for me at least, it doesn't really matter all that much because learning coincided with use of the VE and so there was something about the context that was useful and important (Mitchell et al., submitted). Moreover, as Crook (1991) argues, the context of learning (e.g. within a classroom) should be a central consideration to the design and use of ICT resources because it is always within such a context that we would expect the real world outputs of our research to be used to (hopefully) beneficial effect:

"In order to expose where and how computers are proving potent, the design of evaluations must be sensitive to events that are taking place in the 'periphery' of the individual learner-computer interaction. In particular, evaluation should be amenable to the idea that properties of any computer application include the character of social processes that it supports during the circumstances of use" [8].

Separating out, or attempting to narrow down, the specific factors that promote learning may only be relevant if we are interested in claiming that VEs are *better than* other formats/tools/ contexts for facilitating learning and I would question the usefulness of such a claim or pur-

suit of one. For if we are in the business of putting the needs of participants first and pursuing a research agenda that could be of substantial educational benefit to people with ASDs, then I think that VEs as an option amongst many for the promotion of learning is not only *good enough* but also *appropriate* and *desirable.* This will help to ensure that teachers, parents and therapists can be equipped with a toolkit of possibilities that could be used where appropriate with different children with very different needs. Ultimately, the children benefit if there are a range of stimuli and contexts in which learning takes place and that should be 'what's in it for them'!

REFERENCES

1. Beardon, L., Parsons, S. & Neale, H. (2001). An inter-disciplinary approach to investigating the use of virtual reality environments for people with Asperger Syndrome. Educational and Child Psychology, 18, 53-62.
2. Bernard-Opitz, V., Sriram, N. & Nakhoda-Sapuan, S. (2001). Enhancing social problem solving in children with autism and normal children through computer-assisted instruction. Journal of Autism and Developmental Disorders, 31, 377-384.
3. Brown, D.J., Neale, H.R., Cobb, S.V.G. and Reynolds, H. (1999). Development and evaluation of the virtual city. International Journal of Virtual Reality, 4, 28-41.
4. Chen, S. H. A. & Bernard-Opitz, V. (1993). Comparison of personal and computer-assisted instruction for children with autism. Mental Retardation, 31, 368-376.
5. Cheng, Y. (2005). An avatar representation of emotion in Collaborative Virtual Environments (CVE) technology for people with autism. Unpublished PhD thesis, School of Computing, Leeds Metropolitan University, UK.
6. Clancy, H. (1996). Medical field prescribes virtual reality for rehabilitation therapy. Computer Reseller News, 698, p.76.
7. Cobb, S., Beardon,L., Eastgate, R., Glover, T., Kerr, S., Neale, H., Parsons, S., Benford, S., Hopkins, E., Mitchell, P., Reynard, G. and Wilson, J.R. (2002). Applied Virtual Environments to support learning of Social Interaction Skills in users with Asperger's Syndrome. Digital Creativity,13,11-22
8. Crook, C. (1991). Computers in the zone of proximal development: implications for evaluation. Computers & Education, 17, 81-91.
9. Fabri, M & Moore, D. (2005). The use of emotionally expressive avatars in Collaborative Virtual Environments. Paper presented at AISB 2005. http://aisb2005.feis.herts.ac.uk/index.html
10. Heimann, M., Nelson, K., Tjus, T., Gilberg, C. (1995). Increasing reading and communication skills in children with autism through an interactive multimedia computer program. Journal of Autism and Developmental Disorders, 25, 459-480.
11. Kerr, S.J. (2002). Scaffolding - Design issues in single and collaborative virtual environments for social skills learning. Proc. 8thEGVE. In W. Sturzlinger, S Muller (Eds), 81-91 Barcelona, 29th-30th May 2002.
12. Mitchell, P., Parsons, S. & Leonard, A. (under review). Using virtual environments for teaching social understanding to adolescents with autistic spectrum disorders. Unpublished manuscript, University of Nottingham, UK.
13. Moore, M. & Calvert, S. (2000). Brief report: Vocabulary acquisition for children with autism: teacher or computer instruction. Journal of Autism and Developmental Disorders, 30, 359-362.
14. Nassiri, N., Powell, N. & Moore, D (2005). Avatar gender and personal space invasion anxiety level in desktop collaborative virtual environments. Virtual Reality, published online 15th January 2005.
15. National Autistic Society (UK) (2001). Computer applications for people with autism. Accessed online at www.nas.org.uk (March 2005).
16. Neale, H.R., Cobb, S.V. and Wilson, J.R. (2002). A front-ended approach to the user-centred design of Virtual Environments. Proc. IEEEVR 2002, 24th-28th March, 191-198.
17. Parsons, S., Beardon, L., Neale, H. R., Reynard, G., Eastgate, R., Wilson, J. R., Cobb, S. V., Benford, S., Mitchell, P., & Hopkins, E. (2000). Development of social skills amongst adults with Asperger's Syndrome using virtual environments: The AS Interactive project. Proceedings of the 3rd International Conference on Disability, Virtual Reality and Associated Technologies, Sardinia, 23-25th September, 2000, pp. 163-170.
18. Parsons, S., Leonard, A. & Mitchell, P. (in press). Virtual environments for social skills training: comments from two adolescents with

autistic spectrum disorder. Computers & Education.

19. Parsons, S. & Mitchell, P. (2002). The potential of virtual reality in social skills training for people with autistic spectrum disorders. Journal of Intellectual Disability Research, 46, 430-443.

20. Parsons, S., Mitchell, P., & Leonard, A. (2004). The use and understanding of virtual environments by adolescents with autistic spectrum disorders. Journal of Autism and Developmental Disorders, 34(4), 449-466

21. Parsons, S., Mitchell, P., & Leonard, A. (2005). Do adolescents with autistic spectrum disorders adhere to social conventions in virtual environments? Autism, 9, 95-117.

22. Silver, M. & Oakes, P. (2001). Evaluation of a new computer intervention to teach people with autism or Asperger syndrome to recognize and predict emotions in others. Autism, 5, 299-316.

23. Strickland, D. (1996). A virtual reality application with autistic children. Presence: Teleoperators and Virtual Environments, 5, 319-329.

24. Strickland, D., Marcus, L.M., Mesibov, G.B. & Hogan, K. (1996). Brief report: Two case studies using virtual reality as a learning tool for autistic children. Journal of Autism and Developmental Disorders, 26, 651-659.

25. Trepagnier, C.G. (1999). Virtual environments for the investigation and rehabilitation of cognitive and perceptual impairments. NeuroRehabilitation, 12, 63-72.

26. Wilson, B.A., Alderman, N., Burgess, P.W., Emslie, H.C. and Evans, J.J. (1986). Behavioural Assessment of the Dysexecutive Syndrome. Thames Valley Test Company: Flempton, Bury St. Edmunds.

Contact

Sarah Parsons
School of Education
University of Birmingham
Edgbaston, Birmingham, B15 2TT, UK
Email: s.j.parsons@bham.ac.uk

Abstracts from CyberTherapy 2005, June 6-10, 2005, Basel, Switzerland

Presenter: Mariano Alcañiz PhD

REAL TIME CHANGING VIRTUAL ENVIRONMENTS: A NEW TOOL FOR VIRTUAL THERAPY

M. Alcañiz, Ph. D., Beatriz Rey, M.Sc.; Javier Montesa, M.Sc.; José Antonio Lozano, Ph.D.; M. Carmen Juan, Ph. D.

Medical Image Computing Laboratory (MedICLab), Valencia, Spain

Research Status: Complete.

Environments used up to now for therapeutic applications are invariable ones whose content cannot be changed by the therapist or by the patient. However, this is a technical issue that can be solved with current technology. In this paper, we describe a virtual environment that has been developed taking into account this factor. The main technical feature of the environment is that its aspect can be controlled and modified by the therapist that conducts the clinical sessions depending on the emotions that the patient is feeling at each moment.
The applications of these dynamic changes are not limited to the field of clinical psychology. They open a new arena of possibilities for many other kinds of applications including industry, architecture, medicine, etc. The virtual environment that is described in this paper is a step towards a truly adaptive display.

Contact:
Mariano Alcañiz, PhD
Medical Image Computing Laboratory (MedICLab)
Technical University of Valencia
Camino Vera s/n
46022 Valencia (Spain)
malcaniz@degi.upv.es
Ph: +34 963877517
Fax: +3496 3879510

Presenter: Mariano Alcañiz PhD

ARSPIDERS. A NEW SYSTEM FOR THE TREATMENT OF ARACHNOPHOBIA

Juan, M.C.[1], Botella, C. [2], Baños, R.[3], Guerrero, B. [3], Alcañiz, M. [1], Rey, B.[1], Gil, J. A.[1]

[1] MedICLab (Universidad Politécnica de Valencia)
[2] Departamento de Psicología Básica y Psicobiología (UJI)
[3] Universidad de Valencia

Spider phobia could be a great problem for people who suffer from this kind of phobia and they have to visit or to stay in places where these insects could appear. Exposure therapies and Virtual Reality applications have proved to be effective, but till now Augmented Reality (AR) has not been used in this kind of treatments. We have developed the first AR system for the treatment of arachnophobia. Our AR system was developed using ARToolKit software. We have modelled three different types of spiders. These spiders move their legs. Both the model and the basic movements have been modelled using 3DStudio Max. Textures are created using Adobe Photoshop 7.0. Objects have been exported to VRML format. GLUI Library has been used to develop the Graphic User Interface. To include sounds, OpenAL Library has been used. When the patient or the therapist kills a spider using a flyswatter, the system plays a squishing sound like when you kill a real spider. If the patient or the therapist uses an insecticide, the system plays the sound of a spray can like when you use a real insecticide. The user can choose that one or more spiders appear/disappear. Spiders can appear/ disappear in increments of 3 or 20. When more spiders have to appear, they appear randomly and half of them are close to the center and they can move towards the outside of the image. The rest of the spiders are far away as possible from the center and they can move towards the center. Four patients have been treated with the system. They met DSM-IV criteria for phobia to small animals specifically, fear of spiders. Three of them were females and one male. The exposure directives of Öst were followed in order to carry out the exposure session. The sessions were about one hour. Subjective units of discomfort scale (SUDS) (0=no anxiety,

10=high anxiety) was used to measure the degree of anxiety during the AR exposure. The anxiety level in some moment of the exposure sessions arrived to 10 and decreased till 0. So, the system stimulated anxiety level of patients. Before the exposure session, patients had to enter to a room where a spider was inside a box. None of them were able to interact with the alive spider. After the AR session, patients were able to interact and to kill by themselves real spiders. So, our system has helped four people to overcome their spider phobia in one hour of AR exposure session. We are going to test our system with more patients. Patients also answered three questions related to the degree of presence experienced in the AR session. All patients scored more than 7 (0-10 scale) in all questions. These scores reflect the high sense of presence and reality judgment that the patients experienced. This first system and its first results demonstrate that AR can be successfully applied to psychological treatments. We hope that new AR applications would be developed in future to treat other kind of phobias.

Contact:
Mariano Alcañiz, PhD
Medical Image Computing Laboratory (MedICLab)
Technical University of Valencia
Camino Vera s/n
46022 Valencia (Spain)
malcaniz@degi.upv.es
Ph: +34 963877517
Fax: +3496 3879510

Presenter: Micheline Allard PhD

EFFECTIVENESS OF CBT DELIVERED THROUGH VIDEOCONFERENCING AND FACE-TO-FACE FOR PANIC DISORDER WITH AGORAPHOBIA

Micheline Allard, PhD Candidate & Stephane Bouchard, PhD

University of Quebec in Outaouais Cyberpsychology Lab

Cognitive-behavior therapy is a well validated psychological treatment for anxiety disorders. However, less than 15% of people suffering from an anxiety disorder receive CBT or effective medication. One possible explanation is that patients don't have access to CBT therapists. Videoconferencing could be use to increase the accessibility of validated treatment (i.e., CBT) to reach patients. It is important to determine is videoconferencing can be efficient to give a psychological treatment. The aim of the study is to compare the effectiveness of a validated treatment delivered through videoconferencing and face-to-face.

Method/Tools

For the study, 30 participants (15 = condition face-to-face; 15 = videoconferencing) were SCID-diagnosed in a face-to-face interviews. All participants were referrals to a mental clinic in Montreal (remote site 180 km distance from the local site) or in Gatineau (local site). The selection criteria were: 1) principal diagnosis of panic disorder with agoraphobia; 2) duration of illness for more than 6 months; 3) not receiving concurrent psychotherapy; 4) no comorbid diagnosis invalidating the study. All participants received 12 individual weekly sessions of cognitive-behavior therapy. The efficacy measures were completed at pre- and post-treatment and included the Panic and Agoraphobia Scales and the Agoraphobic Cognitions Questionnaire.

Results

For all the measures, the results demonstrated significant improvement ($p<.05$) for all the participants in both conditions (face-to-face and videoconferencing).

Conclusion

These results of the study show the effectiveness of the cognitive-behavioral therapy delivered through face-to-face and via videoconferencing. Those results may have an impact on the availability and the distribution of mental health services for panic disorder with agoraphobia and other anxiety disorders.

Contact:
Micheline Allard, Ph.D. Candidate
Micheline_Allard@hotmail.com
Phone: (819) 771-7761 ext.8419
Fax: (819) 776-8098

Presenter: Angelos Amditis PhD

THE ISLANDS SYSTEM: A MODULAR

NON-CONVENTIONAL E-MENTAL HEALTH SYSTEM TO SUPPORT SERVICES TO REMOTE AREAS

Dr. Angelos Amditis[1], Ms. Zoi Lentziou[1], Dr. Euangelos Bekiaris[2], Dr. Maria Fernanda Cabrera[3], Dr. Alex Bullinger[4]

[1] Institute of Communication and Computer Systems (ICCS)
[2] Center for Research and Technology Hellas/ Hellenic Institute of Transport (CERTH/HIT)
[3] Telecommunication Engineering School, Technical University of Madrid (UPM)
[4] Center of Applied Technologies in Mental Health (COAT)

This paper is the output of the work performed in all multidisciplinary tasks of the WP, while focusing on defining the technical specifications and operative scenarios for the ISLANDS system in order to develop services to provide modular, non-conventional, remote psychiatric and psychotherapeutic assistance for remote areas.

The ISLANDS project basically aims at:

- Improving the quality of life of the users,
- Enhancing the quality of mental health care and the economic strength of the region
- Overweighting the costs of implementation and service support.
- Reducing inequalities in mental health services and status among European regions.

Building a complicated system like the ISLANDS system was a time consuming and complicated task, since the combination of both the delivery of three different services (i.e. screening, counselling and therapy) to three different target groups (i.e. general practitioners, patients and their carers) and the compatibility between the standards and the situation that exists in three different European areas (Spain, Greece and France) is required. This is the reason why a thorough analysis regarding the specifications and the requirements of the various components and the peripheral devices of the overall system has taken place and an elaborate study for the design of the system architecture has been carried out.
Primarily, the architecture of the ISLANDS system takes the following parameters into account:

- The various current technical ways of establishing e-mental health and their requirements in relation to the existing equipment in the area of telemedicine in general.
- Cost efficiency issues.
- Liability.
- Risk analysis

The User (i.e. General Practitioner, Patient and/or relative) can have access through the network (i.e. Internet) to the ISLANDS Multi-Access Center. The IMAC has the potentials to allow users to access the remote services whatever access terminal or combination of terminals they may choose to use.
IMAC consists of four parts mainly:

- the ISLANDS database
- the ISLANDS router
- the ISLANDS tools and
- the Knowledge Management Organiser

It is self evident that in most of the cases the data transmission urgency should be taken into consideration. This means that since the service delivery frequency is dependent on the type of the content, the format and the importance of the transmitted medical data were identified and therefore the technology that should be used was defined to cover the application needs. For instance, screening a patient, which can be considered as a low importance service delivery, can be supported by text. The technology that can be used in that case is possibly the mail. On the other hand, providing guided therapy to the patient, which is a case of high significance and importance, require the transmission of video (audio and visual contact with the doctor). This leads to the conclusion that the technology that could be used to apply this situation is Videoconference or Computer conference.

Presenter: Rosa Maria Banos PhD

USING "TRADITIONAL" STRATEGIES IN A "VIRTUAL WORLD" FOR THE TREATMENT OF PATHOLOGICAL GRIEF

Baños, R. [2], Botella, C. [1], García-Palacios, A. [1], Quero, S. [1], Lasso de la Vega, N. [1], Guillén, V. [2] & Osma, J.

[1] Universitat Jaume I Castellon. (Spain).
[2] Universidad de Valencia (Spain).

During the last decade notable advances in the psychological treatments field have been produced. At this moment an important amount of effective treatments or "based on evidence" treatments (*Task Force on Promotion and Dissemination of Psychological Procedures,* 1995) are available. The cognitive model has had a notable contribution for this important advance to be achieved, however, from a therapy perspective, this model is still far away from understanding and controlling the human change processes. These insufficiencies come from the theoretical shortcomings, that is, there exist discrepancies between the lineal logic of many of the cognitive perspectives and the complexity of human functioning. Within these insufficiencies is worth to point out the scarce attention that has been paid to emotions in therapy for a long time.

One of the objectives of the European project EMMA (*Engaging Media for Mental Health*) is to examine the possibility of using new technologies (virtual reality) with the aim of treating emotions from a different perspective than the traditional one. In the EMMA project we have developed a series of emotional devices which can be customized so they can be full of meaning and contain the fundamental elements that the person has to cope with. That is, our objective is to try to show in a physical way the personal meanings and the emotions associated to those meanings and to examine to which extent this strategy helps the person in the process of change. The purpose is to create a series of "experiences" in therapy that can be used to activate, correct, structure, and restructure previous life experiences that can serve as cognitive-emotional structural frames from which a new way of processing and integrating present, past, and future experiences can be structured. In this work we present the EMMA environment and the clinical treatment protocol for pathological grief in a case study.

Contact:
Rosa Maria Banos, PhD
Universidad de Valencia. Spain
banos@uv.es
Phone +34 963864412
Fax: +34 963864669

Presenter: Rosa Maria Banos PhD

THE ROLE OF PRESENCE AND REALITY JUDGMENT IN VIRTUAL ENVIRONMENTS IN CLINICAL PSYCHOLOGY

Banos, R.M.[1], Quero, S[2]. Salvador, S[1]. & Botella, C[2].

[1]Universidad de Valencia (Spain).
[2]Universitat Jaume I. Castellon (Spain).

Presence and Reality Judgment are two important variables to take into account in the Virtual Reality (VR) field. So far, scientific literature has paid attention to the construct of presence, and several assessment measures are available. However, the concept of Reality Judgment has received less attention, and usually, it has been subsumed into the concept of presence. No too much effort has been dedicated to test whether or not both constructs refer to the same domain. In a previous work, our team developed a 78-item self-report questionnaire that assesses both constructs: sense of presence and reality judgment (Banos et al., 2000). This was applied to 124 undergraduate students from the University Jaume I of Castellón (Spain) and the University of Washington (Seattle). A three factor solution was obtained: a reality judgment factor, an interaction/external correspondence factor and an attention/ absorption factor. While the reality judgement items grouped in a single factor, items concerning presence were watered down among the three obtained factors. We believe that the sample employed had influenced remarkably on the results. The scenarios where the participants were immersed did not stimulate any type of emotion (those participants that could have had the slightest problem in any of the environments were excluded), and this fact prevented any emotional involvement or internal correspondence factors from showing up. The following task was to apply the questionnaire to clinical samples to elucidate whether the same or different factors emerged. Preliminary results obtained with clinical and subclinical participants belonging also to Spanish and North American samples showed that in VR applications for Clinical Psychology emotion was playing an important role in the sense of presence and the reality attribution of users (Banos et al., 2001). In this case, the virtual environments were able to elicit emotions in

the participants, so items related to emotions and sensations were the most important. However, an important shortcoming of this study was the small size of the sample (N=112). Therefore, the aim of the present work is to apply the Presence and Reality Judgement Questionnaire to a larger clinical and subclinical sample.

References

Baños, R.M., Botella, C., Garcia-Palacios, A., Villa, H., Perpiña, C.& Alcañiz. M. (2000). Presence and reality judgment in virtual environments: A unitary construct?. *CyberPsychology and Behavior, 3* (3), 327-335,

Baños, R. M., Botella, C., García Palacios, A., Perpiñá, C., Quero, S. & Gallardo, M. (2001). The Role of Reality Judgment and Presence in Virtual Environments for Clinical Psychology. *World Congress of Behavioral and Cognitive Therapies.* Vancouver. July 17-21.

Contact:
Rosa Maria Banos, PhD
Universidad de Valencia. Spain
banos@uv.es
Phone +34 963864412
Fax: +34 963864669

Presenter: Azy Barak PhD

FACTORS RELATED TO SUCCESS OF HELPING HIGHLY DISTRESSED INDIVIDUALS THROUGH EMOTIONAL SUPPORT ONLINE CHAT

Azy Barak, PhD

University of Haifa

The purpose of the study was to examine the contribution made by dimensions of session impact (experts' evaluation of session process, that includes factors of depth and smoothness, and experts' evaluation of post-session factors of client's mood, that includes positivity and emotional arousal) and of several textual variables (positive and negative emotional expressions; helper's and client's writing length) to the success of emotional support conversations carried out by trained, paraprofessional helpers on an Internet chat with highly distressed individuals. Two studies were conducted at SAHAR, an exclusively online, Israeli emotional support service for suicidal and highly distressed people who had experienced various negative conditions, including those related to rape and sexual abuse, eating disorders, depression, social anxiety, drinking and drug use, homosexuality, and domestic violence. Study 1 compared 40 successful conversations (as indicated by clients at the termination stage of session) executed through instant messaging and chat tools with 40 other conversations (not indicated as successful by clients), using expert judgments, on session-impact dimensions as well as objective word count for textual variables. Study 2 examined correlations between helpers' evaluation of the sessions' contribution to clients in 60 (other) support conversations and session impact factors and textual dimensions. The findings of Study 1 showed that all four impact dimensions, as well as expression of negative emotions, significantly differentiated between successful and unsuccessful conversations. In Study 2, the results showed that all four impact dimensions positively correlated with helpers' evaluations (yielding multiple R=.54), as well as the length of helper's and client's writing. The implication of these studies are that similar to offline counselling sessions, deep, smooth conversations that yield positive responses and arouse clients' emotions in online support are more successful than shallow, bumbling conversations that leave clients emotionally indifferent. Ventilating negative feelings and more expression in writing, by both helpers and clients, seem to be important factors, as well.

Contact:
Azy Barak, PhD
Department of Education
University of Haifa
Haifa, Israel 31905
Phone: +972-4-8249374
Fax: +972-4-8240911
Email: azy@construct.haifa.ac.il

Presenter: Mihaela Ioana Baritz PhD

THE IMPROVEMENT OF THE AUDIO-VIDEO TECHNIQUES AND VIRTUAL ENVIRONMENT USED FOR INVESTIGATION METHODS AND ASSISTED PEOPLE WITH DISABILITIES

Mihaela Ioana Baritz PhD

University of Transylvania Brasov

In this paper we propose an improvement method of audio video techniques and smart environment for optimization and objective methods of investigation in the bio-systems and for the disadvantage people assisting. Taking in account the necessity for development, the new facilities and services it is proposed the accomplish a modulated infrastructure which can generate the optimum systems for different investigations of the health problems, the creation of the smart environments for the medical assistance, the generation of new methods-virtual reality- to prevent the deficiencies installation to the children and adults. The most important objectives of the researches are: the implementation of this health investigation, assisting and information structure into public service by e-Health systems, the evaluation of the research impact on the assurance of the compatibilities demands for Romania integration in European system, and also the using of the methods like virtual reality and biotelemetry, for developing of the news way to assist the people.

Contact:
Mihaela Ioana Baritz PhD
University of Transylvania Brasov
B-ul EROILOR nr. 29,
Brasov, 2200
R O M A N I A
Phone: 0040.268.416352
Email: mbaritz@unitbv.ro

Presenter: Cristina Botella PhD

THE TREATMENT OF EMOTIONS IN A VIRTUAL WORLD. APPLICATION IN A CASE OF POSTTRAUMATIC STRESS DISORDER

Botella, C., Ph.D.[1], Garcia-Palacios, A. Ph.D., [1], Banos, R., Ph.D.,[2], Guillen, V.[1], Quero, S., Ph.D.[1], Lasso de la Vega, N. [1] & Osma, J. [1]

[1] Universitat Jaume I Castellon. (Spain).
[2] Universidad de Valencia (Spain).

During the last decade notable advances in the psychological treatments field have been produced. At this moment an important amount of effective treatments or "based on evidence" treatments (*Task Force on Promotion and Dissemination of Psychological Procedures,* 1995) are available. The cognitive model has had a notable contribution for this important advance to be achieved, however, from a therapy perspective; this model is still far away from understanding and controlling the human change processes. These insufficiencies come from the theoretical shortcomings, that is, there exist discrepancies between the lineal logic of many of the cognitive perspectives and the complexity of human functioning. Within these insufficiencies it is worth to point out the scarce attention that has been paid to emotions in therapy for a long time.

One of the objectives of the European project EMMA (*Engaging Media for Mental Health*) is to examine the possibility of using new technologies (virtual reality) with the aim of treating emotions from a different perspective than the traditional one. In the EMMA project we have developed a series of emotional devices which can be customized so they can be full of meaning and contain the fundamental elements that the person has to cope with. That is, our objective is to try to show in a physical way the personal meanings and the emotions associated to those meanings and to examine to which extent this strategy helps the person in the process of change. The purpose is to create a series of "experiences" in therapy that can be used to activate, correct, structure, and restructure previous life experiences that can serve as cognitive-emotional structural frames from which a new way of processing and integrating present, past, and future experiences can be structured. In this work we present the EMMA environment and the clinical treatment protocol for posttraumatic stress disorder in a case study.

References

American Psychological Association Task force on Psychological Intervention Guidelines (1995). *Template for developing guidelines: Interventions for mental disorders and psychological aspects of physical disorders.* Washington, D. C.: American Psychological Association.

Contact:
Botella, C., Ph. D.
Universitat Jaume I. Castellon. Spain
botella@psb.uji.es
Phone: +34 964728881
Fax: +34 964729267

Presenter: Cristina Botella PhD

MIXING REALITIES? AN AUGMENTED REALITY SYSTEM FOR THE TREATMENT OF SPIDERS AND COCKROACHES PHOBIA

Botella, C. [1], Baños, R. [2] Guerrero, B. [1], Juan, M. C. [3] & Alcañiz, M., Ph. D. [3]

[1] Universitat Jaume I Castellon. (Spain).
[2] Universidad de Valencia (Spain).
[3] Medical Image Computing Laboratory (MedICLab). Technical University of Valencia (Spain)

Augmented Reality (AR) consists of introducing virtual elements in the real world. That is, the person is seeing an image conformed by a visualization of the real world and by a series of virtual elements that are over-imposed in the real world. The main aspect of AR is that virtual elements provide relevant and useful information to the person that does not exist in the real world. AR has a high potential and has been already used in several fields: medicine, army, training, engineering, design, robotic, etc. Up to now AR has not been used in the psychological treatments area. However, AR presents several advantages. Like in the classic virtual reality systems, it is possible to have a total control over the virtual elements over-imposed in the real world and how to interact with them. But, AR has and additional advantage: it facilitates the person's sense of presence (the sense of being there) and reality judgment (to judge the experience as real). This is possible because the environment where the person is placed and what the person is seeing are, in fact, "the reality". In this work the data of a series of case studies in which AR has been used for the treatment of specific phobia (spiders and cockroaches phobia) are presented. Results are very promising. The patients showed a high degree of fear and avoidance in the behavioural avoidance test at pre-test and, these scores not only decreased after treatment, but the patients were able to approach, interact and kill alive insects.

Contact:
Botella, C., Ph. D.
Universitat Jaume I. Castellon. Spain
botella@psb.uji.es
Phone: +34 964728881
Fax: +34 964729267

Presenter: Stéphane Bouchard PhD

RELIABILITY AND VALIDITY OF A SINGLE-ITEM MEASURE OF PRESENCE IN VR

Stéphane Bouchard, Geneviève Robillard, Julie St-Jacques, Stéphanie Dumoulin, Marie-Josée Patry & Patrice Renaud

Université du Québec en Outaouais

Research Status: Completed.

Measuring the subjective feeling of presence in virtual environments usually relies on questionnaires. These instruments are long and, while many items are useful to tap the diverse subtleties and dimensions of a construct, it poses a significant challenge if a researcher wants to measure presence during a VR immersion. This presentation will document the validation process of a single-item measure of presence. The question «To which extend do you feel present in the virtual environment, as if you were really there» was subjected to: a content and face validity study, two test-retest reliability studies, a convergent and divergent validity study, and two sensitivity studies.

Content and face validity

The goal of the first study was to ascertain that the single-item presence is well understood by the general population. A community sample of 49 adults (mostly low to moderate socio-economic status and not highly educated) were immersed for 7 minutes in a virtual environment in a shopping mall. After the immersion, participants rated on a scale from 0 to 10 how well they understood the meaning of the item, as well as the meaning of control items (including items from other popular presence measure). The results showed that the question was very well understood. The clarity if the question was as good as controlled items drawn from a psychological test validated for adults with the reading ability of a grade-five population. The clarity was statistically better than the control items that were designed to be difficult to understand (e.g., items with double-negatives).

Test-retest

A sample of 31 university students completed

the presence question on two occasions during a 7 minutes VR immersion, and another sample of 26 adults completed the presence question after two different VR immersions. The test-retest coefficients were very high (.21 and .83, respectively).

Convergent and divergent validity

The single-item measure of presence correlates significantly with the *Presence Questionnaire*, and much less with *Perceived Realism* and the *Immersive Tendencies Questionnaire*.

Sensitivity

Two studies were devised to assess the sensitivity of the item to experimental manipulations. In the first study, 33 participants were immersed twice in the same virtual under a condition that maximise presence and under a condition that hinder presence. In a second study, 29 snake phobics were subjected to psychological manipulations where anxiety was induced or not by leading them to believe that the virtual environment could contain dangerous hidden snakes. In both studies, the repeated measures ANOVA confirmed the sensitivity of our measure.

Conclusion and novelty

Item-response theory would recommend to be careful in using only one item to measure a construct, while practical factors such as distraction would militates in favour of using the least intrusive measure as possible. The validation process confirmed that a single-item measure of the subjective feeling of presence is well understood, reliable and valid. These results will be very useful for any researcher interested in measuring presence while users are immersed in a virtual environment. The presentation of the results of each study should also be of interest to the audience.

Contact:
Stéphane Bouchard
Université du Québec en Outaouais
Stephane.bouchard@uqo.ca

Presenter: Eileen Brosnan

TRANSFORMING STORIES: A MULTIMEDIA TOOL FOR THERAPEUTIC STORY BUILDING WITH CHILDREN AND ADOLESCENTS

Eileen Brosnan, Research Fellow[1], Dr. John Sharry[2], Richard Boyle[1], Prof Carol Fitzpatrick[3]

[1]Media Lab Europe
[2]Mater Hospital, Dublin
[3]University College Dublin

Background

In child and adolescent therapy, multimedia is most commonly used where the child and therapist use professionally made CD-ROM's of interactive stories, computer games, or internet resources to access information and facilitate communication. This involves listening, watching, and reading. The interactive elements allow users a degree of control over the narrative and direction of a story. This is mainly passive. "Transforming Stories" takes it a step further by using multimedia in therapy in a constructive way, allowing the child to build their own story. In his research in the field of education Papert (1996) highlighted the importance of children making their own artifacts, something that is a real reaction to their world. This premise can also be applied to the therapeutic process.

Method/Tools

Transforming Stories is a database driven multimedia storytelling tool delivered both online and on stand alone platform. The software currently being developed will allow the users to choose a story template and build up the story plot using customisable characters and background scenes, adding in their own voiceover and animation. The authoring timeline is presented in an immediate way using a drag and drop facility for placing story objects and further features such as positioning tools, playback and story editing. There is also a text tool allowing them to integrate their own captions. Other options include building from seed stories where they can change the plotline and add in their own characters and dialogue. Finally they can upload and share their stories to an online community.

In the method, the therapist introduces the idea of making a story and shows examples of what is possible using the software. It can be a story tailored to a problem that needs resolution or a general story that brings about some positive change in the storyline. A key

therapeutic feature is a notebook facility where the child and therapist keep a log of their thoughts on the process and their analysis of the story. This allows for reflection and gives the therapist the opportunity to prompt new ideas for problem solving.

Evaluation

The current research focuses on evaluating the therapeutic use of multimedia authoring tools now being widely used in the classroom setting. This research is based on case study examination of the benefits of using these tools in engaging adolescents and progressing the therapeutic relationship in a small sample of adolescents attending the Mater Child and Adolescent Psychiatry Service, Dublin, Ireland.

The second stage of the research will involve the initial testing of "Transforming Stories" across a range of client groups and professional disciplines including Psychotherapy, Social Work, Psychology, and Psychiatry. This testing will involve a qualitative study.

Novelty/Discussion

"Transforming Stories" is an innovative new approach to eliciting stories in child and adolescent therapy. Over time the online forum will provide an expanding database of story building material to be drawn from. The planned integration of drawing tools and other authoring features will give increase the creative dimension and allow the users to create uniquely designed work.

References

Schafer, C. (1999). "Innovative Psychotherapy Techniques in Child and adolescent Therapy." USA: Wiley & Son.
Papert, S. (1996) "The Connected Family: Bridging the Digital Generation Gap", Atlanta, USA: Longstreet Press.
Goss, S., Anthony, K. (2003) "Technology in Counselling and Psychotherapy: A Practitioner's Guide" New York: Palgrave Macmillan.
Hsiung, R.C. (2002) "e-Therapy: Case Studies, Guiding Principles, and the Clinical Potential of the Internet", New York: W.W. Norton & Company.

Contact:
Eileen Brosnan
Department of Child and Family Psychiatry
Mater Hospital
Dublin 7, Ireland
Tel: 00353 1 803 4793
Email: eileen.brosnan@tcd.ie

Presenter: Eileen Brosnan

'WORKING THINGS OUT' A THERAPEUTIC INTERACTIVE CD-ROM CONTAINING THE STORIES OF YOUNG PEOPLE DEALING WITH DEPRESSION AND OTHER MENTAL HEALTH PROBLEMS

Dr. John Sharry[1], Eileen Brosnan, Research Fellow[2], Prof Carol Fitzpatrick[3]

[2]Media Lab Europe
[1]Mater Hospital, Dublin
[3]University College Dubli

Acknowledgements

In developing this project we would like to acknowledge the work of Bernie McCarthy, Ciara Devine, Pilar Valencia, Hugh O'Neill, Peter McCormack and John Stapleton from the production team.

It is widely accepted that children and young people enjoy using computers. Seymour Papert (1996) suggests that 'it is timely for school counsellors and child therapists to bridge the digital generation gap and innovate with computers in their work with children of the digital age.' Working Things Out (WTO) was developed in response to the growing need for computer-based resources for adolescents in therapy. It is an interactive CD ROM/DVD developed as a means of engaging adolescents about mental health issues by giving them information in the form of animated personal stories told by other young people dealing with problems such as depression, bullying, eating problems, and self-harm. The CD-ROM/DVD is accompanied by a manual for professionals on how to use the resource.

With the help of therapists, and in collaboration with graphic designers, animators, and multimedia professionals, the 11 young people who participated in the project told their stories, narrated in their own voice, and illustrated by graphics and animation. 'Working Things Out' is currently being used as an educational and therapeutic tool with other

adolescents at risk of mental health problems, both as a way of engaging young people to reflect about mental health issues and as a means of inviting them to tell their own story. The paper describes the background and development of the 'Working Things Out' project, including samples from the stories and a description of how the CD-ROM/DVD can be used in psychotherapy.

References

1. Offer, D., Howard, K.I., Schonert, K.A., Ostrov, E., To whom do adolescents turn for help? Differences between disturbed and non-disturbed adolescents. J. AM. Acad Child Adolescence Psychiatry, 30:623-630, (1991).
2. US Department of Health and Human Services, Mental Health: A Report of the Surgeon General, Rockville, MD: US Department of Health and Human Services, (1999)
Sharry, J., Counselling Children, Adolescents and Families. Sage, London, (2004).

Contact:
Dr John Sharry
Dept of child and family psychiatry
Mater Hospital
Dublin 7 Ireland
Tel: +353 1 803 4793
Emai: Eileen.brosnan@tcd.ie

Presenter: Alex H. Bullinger MD MBA

NEXT GENERATION IMMERSIVE VISUALIZATION SYSTEMS

Alex H. Bullinger[1]

[1] COAT-Basel / UPK (Center of Applied Technologies in Neuroscience), University of Basel, Switzerland

This paper deals with the ongoing developments towards immersive 3-D displays that require no special eyewear like shutter glasses anymore. Once these devices will have penetrated the market to a larger scale they could easily mark the end to the era of huge rear projection – based installations such as Powerwalls or CAVE – systems. At present only a handful of these 3-D display devices are on the market, most of them still promising more than what they are able to fulfill in the end. But technology development in this sector is moving with utmost velocity and ferocity. By the end of 2005 marketing of desktop 3-D displays will begin in earnest opening up a vast number of potential applications not only for scientist, engineers and IT specialists but literally for everybody.

Contact:
Alex H. Bullinger
COAT-Basel / UPK
Wilhelm Klein – Str- 27
4025 Basel, Switzerland
bua@coat-basel.com

Presenter: Alex H. Bullinger MD MBA

TREATING ACROPHOBIA IN A VIRTUAL ENVIRONMENT

Alex H. Bullinger[1], Isabelle Angenendt[1], Brenda K. Wiederhold[2], Franz Mueller-Spahn[1], Ralph Mager[1]

[1] COAT-Basel / UPK (Center of Applied Technologies in Neuroscience), University of Basel, Switzerland
[2] IMI and VRMC, San Diego, USA

Specific phobias are one of the most frequent mental health problems and can lead to years of personal suffering. The most effective treatment is exposure therapy. Our aim was to proof the feasibility and efficacy of virtual environments in treating acrophobia patients using a manually guided exposure therapy. Our pilot study was designed as a crossover intervention with a waiting list condition as a control group. After treatment, our results show that exposure in virtual environments is a feasible technique can provoke anxiety, and leads to a therapeutic effect.

Contact:
Alex H. Bullinger
COAT-Basel / UPK
Wilhelm Klein – Str- 27
4025 Basel, Switzerland
bua@coat-basel.com

Presenter: Maria Fernanda Cabrera PhD

E-MENT@L HE@LTH. THE ISLANDS PROJECT AS A CHALLENGE FOR THE FUTURE

Maria Fernanda Cabrera PhD

Universidad Politecnica de Madrid

It has been already accepted that the improvement in medical care cannot be made merely by adding professionals to healthcare systems, but in addition require restructuring the patterns of health-care delivery. The incorporation into medical practice of relevant technological innovations is an essential part of this reorganisation. This innovation is producing a promising field - e-mental health - whose focus is the use of communication and information technologies to improve the mental health care processes. This area has developed rapidly, accumulating knowledge and proposing innovative affirmations. This is a multidisciplinary field that requires the cooperation among different professionals. The results of this collaboration are represented by the ISLANDS project, an attempt to develop and comprehend the potential of e-mental health, which specific goal was to develop services to provide modular, non-conventional, remote psychiatric and psychotherapeutic assistance for remote areas.
The project started with a literature review of the state of the art on remote therapeutic psychiatric and psychotherapeutic interventions, complemented by field work with the realization of questionnaires to patients, families and doctors, and an international workshop, to result in appropriate service delivery scenarios.

The scenarios specified, the different user group needs and the epidemiological findings led to the definition of different remote service categories (diagnosis, counseling, and therapy) for patients, informal careers, and professionals, as well as an overall service layout. These services are supported by interactive and user-friendly tools for service content presentation, namely: an interactive web chat tool, a database of reference case studies, an expert tool for therapy guidance, a tool for service confidentiality, and the necessary communication tools and service delivery platforms. All the above developments are integrated into modular service typologies, taking into account relevant security, legal and ethical issues. Four typical case studies of psychological problems have been selected that can be found quite often in normal populations and are of specific interest: post-traumatic stress disorder, depression, problems of alcohol abuse, and psychotic disorders. The proposed services are being tested in three pilot sites: the French Overseas Departments, the Greek Southern Sporades, and the Spanish western Canary Islands.

Over the past 24 months, the ISLANDS consortium has focused in the development and deployment of feasible tools for diagnostic, counseling, and therapy purposes. According to the preliminary results of a questionnaire survey, users' acceptance of and satisfaction with the technology were high. Ninety percent of the patients considered that they received the follow-up care they required.

We can conclude that the development of a knowledge-based expert tool to guide the relevant services application aims to avert erroneous application of such services, by inexperienced medical personnel or the users themselves and their relatives.

The project will, it is hoped, provide leadership, enhance information about mental health problems, and undertake research in cost-effective policies to improve the mental disorders addressed.

Contact:
Maria Fernanda Cabrera PhD
Universidad Politecnica de Madrid
Madrid 28040
Spain
Phone: +34915495700 ext. 332
Fax: +34913366828
Email: chiqui@gbt.tfo.upm.es

Presenter: Maria Fernanda Cabrera PhD

OPEN MOBILE PLATFORM FOR EMERGENCY HEALTHCARE APPLICATIONS

Maria Fernanda Cabrera PhD

Universidad Politecnica de Madrid

In the new society, mobility has become a necessity and a competitive advantage, both for citizens and the human capital of companies. Its next step is clearly to become a complete product. In order to become a commodity for European society, mobile solutions must provide five main characteristics: ubiquity, transparency, fundamentality, universality, and value governance. As the new 3G technology is "around the corner," suitable platforms that make possible an interesting business model to access Pan-European mobile services is a "must" that hasn't been

resolved, yet. Facing this reality, the European Union funded XMOB, an IST project that joined research groups, phone operators, consultancy companies, industry, and emergency medical services (EMS) to build a platform aimed to host mobile applications. The benefits and outputs of the platform were validated through the development of a vertical application for the health emergency management.

The mobile emergency services developed focused on the following main challenges:

- Necessity to cover a broad set of devices and channels
- Need to integrate a complex range of involved actors (e.g., insurance call centers, public emergency assistance, patients' historical medical records repositories, hospitals, etc.)
- Provision of complete, customized, and timely assistance in emergency situations based on instant and secure mobile access to standardized patients medical records
- Existence of emergency situations that require the coordination between different countries to provide an accurate attention to the patient

The methodological approach consisted of two steps: to build a reusable horizontal platform and then, following an ASP model, to develop vertical mobile applications for health emergency management. These applications were made of several tools that help the emergency staff and the other actors involved in accessing critical data of patients.

The platform was validated in real life situations and cost-effectiveness and patients' benefits analysis were conducted. The trials were carried out in Madrid and Genoa cities and lasted two months.

The opinion of the users consisted of a self-evaluation with a questionnaire distributed to different staff categories. The questionnaires contained closed-ended questions and respondents were provided space to add written comments. The results were evaluated in scores on two scales, the "Usefulness" scale denoting potential use of the system, and the "Satisfying" scale reflecting pleasantness. The patient's privacy and respect issues were covered.

The most important conclusion, which can be derived from the pilots' comparisons, is the fact that all user groups were in all cases and in both pilot sites positively oriented towards the developed system. Nevertheless, it should be remarked that all EMS do not need the same functionalities in their pre-hospital emergency management due to specificity of environments (rural/urban, medical/paramedic) so that the main achievement of this platform is to provide a widely open integrated solution. This will enable any citizen to benefit from the same quality of care, anywhere, in pre-hospital emergencies domain.

The benefits of a seamless infrastructure are the foundational components of this platform that improve the efficiency and efficacy of the EMS. This translates into lives saved and morbidity reduced.

Contact:
Maria Fernanda Cabrera PhD
Universidad Politecnica de Madrid
Madrid 28040
Spain
Phone: +34915495700 ext. 332
Fax: +34913366828
Email: chiqui@gbt.tfo.upm.es

Presenter: Yang Cai PhD

GEDANKEN EXPERIMENT OF HUMAN DYNAMICS

Yang Cai

Carnegie Mellon University

Understanding human dynamics is an important step in clinical therapies, such as blood glucose management or weight control. It requires insight into the complex interactions between the components of biomedical systems. This is challenging because of the enormous amount of data and knowledge in this domain. Gedanken Experiment is an intuitive, qualitative thinking process, which have been used by physicists for decades. Our goal is to enable an interactive game-like environment for users with any background, while remaining sufficiently flexible to target medical problems at a level of abstraction, from the conformational changes of a protein to the interaction of the various biochemical pathways in our body. Here, we present an interactive and visual problem-solving environment for the

biomedical domain. We designed a biological world model, in which users can explore biological interactions by role-playing "characters" such as cells and molecules or as an observer in a "shielded vessel," both with the option of networked collaboration between simultaneous users. The system architecture of these "characters" contains four main components: (1) Bio-behavior is modeled using cellular automata. (2) Bio-morphing uses vision-based shape tracking techniques to learn from recordings of real biological dynamics. (3) Bio-sensing is based on molecular principles of recognition to identify objects, environmental conditions, and progression in a process. (4) Bio-dynamics implements mathematical models of cell growth and fluid-dynamic properties of biological solutions. The principles are implemented in a simple world model of the human vascular system and a biomedical problem that involves an infection by Neisseria meningitides where the biological characters are white and red blood cells and Neisseria cells. Our case studies show that the system can be used for public health education, biomedical simulation and creative problem solving.

Contact:
Yang Cai
Carnegie Mellon University
Email: ycai@cmu.edu

Presenter: Gianluca Castelnuovo PhD

A NEW GENERATION OF VIRTUAL ENVIRONMENTS FOR THE TREATMENT AND REHABILITATION OF EATING DISORDERS

Gianluca Castelnuovo, Ph.D.[1-2-4], Gianluca Cesa, M.S.[1-4], Andrea Gaggioli, M.S.[1-3], Daniela Villani, Ph.D. 1 Enrico Molinari, Psy.D. [2-4], Giuseppe Riiva, Ph.D.[1-2]

[1] Applied Technology for Neuro-Psychology Lab, Istituto Auxologico Italiano
[2] Department of Psychology, Catholic University, Milan, Italy
[3] Laboratory of Psychology, Department of Preclinical Sciences LITA Vialba, University of Milan, Milan, Italy
[4] Clinical Psychology Lab, Istituto Auxologico Italiano, Verbania, Italy

The cognitive behavioral therapy (CBT) is still considered the best approach in the treatment of eating disorders, but it could present different limitations related to costs of typical behavioral procedures or difficulty with cognitive techniques. Virtual Reality has already shown its possible utility in enhancing the CBT for different mental problems. Rationale and protocols about the use of Virtual Reality-enhanced treatments, named Integrated Experiential Therapy (IET), will be explained. The major aim of this presentation is the description of a new paradigm of virtual environments (VEs): new possibilities for different clinical protocols will be discussed. The real novelty of this new generation of VEs is the high level of flexibility and plasticity allowing therapists to save different versions according to the specific users' needs and features. Moreover it is possible to carry on systemic, dynamic or cognitive-behavioural approaches using different aspects and nuances of VEs.

This research is part of the Prof. Giuseppe Riva's NEUROTIV project - Immersive virtual telepresence managed care for the assessment and rehabilitation in neuro-psychology and clinical psychology.

Contact:
Gianluca Castelnuovo, Ph. D.
Applied Technology for Neuro-Psychology Lab
P.O. BOX 18211
28921 Verbania, Italy
Tel. +39/0323/514278- .339
Fax. +39/0323/514338
Email: gianluca.castelnuovo@auxologico.it

Presenter: Gian Luca Cesa MS

INTEGRATED EXPERIENTIAL THERAPY FOR THE TREATMENT OF OBESITY AND BINGE EATING DISORDER: A CLINICAL TRIAL

Gian Luca Cesa, M.S.[1], Gianluca Castelnuovo,
Ph.D.[1], Andrea Gaggioli, Ph.D.[1], Daniela Villani, M.S[1], Giuseppe Riva, Ph.D.[1-2]

[1] Applied Technology for Neuro-Psychology Lab. Istituto Auxologico Italiano, Verbania, Italy
[2] Department of Psychology, Università Cattolica del Sacro Cuore, Milan, Italy

The main goal of this work is the description of a new Virtual Reality-enhanced treatment named Integrated Experiential Therapy (IET) for the treatment of Obesity and Binge Eating

Disorder. IET for eating disorders and obesity is a relatively short-term, integrated, patient oriented approach that focuses on individual discovery. Integrated Experiential Therapy is an integrated approach ranging from cognitive-behavioural therapy to virtual reality sessions for the treatment of eating disorders and obesity. In this approach VR is mainly used to modify body image perceptions. The use of VR offers two key advantages. On one side, it is possible to integrate all different methods (cognitive, behavioural, and experiential) commonly used in the treatment of body experience disturbances within a single virtual experience. On the other side, VR can be used to induce in the patient a controlled sensory rearrangement that unconsciously modifies his/her bodily awareness (body schema).The treatment is a 4-6-week inpatient treatment and it is administered by therapists having a cognitive-behavioural orientation who work in conjunction with a psychiatrist as far as the pharmacological component is concerned. The individual work regards assessment by means of psychometric tests, weekly supportive psychological talks, 7 sessions for assessment, and therapy carried out using Virtual Reality (VR), and psycho-pharmacological assessment and control. The psychological group therapy is based on weekly group meetings (closed group of 5/6 persons) of two hours each. The work group aims both at training for development and acquisition of assertive skills, and at training for assessment and consolidation of motivation. Moreover, the subjects participate to both bi-weekly psycho-nutritional groups held by nutritionists and to daily group sessions of physical activity. In order to verify the efficacy of IET we are realizing a clinical trial with a sample of obese patients (with and without Binge Eating Disorder). Subjects were randomly assigned to the experimental group and to the three control groups. Subjects were assessed by one of three independent assessment clinicians who were not involved in the direct clinical care of any subject. All subjects were assessed at pre-treatment and upon completion of the clinical trial. Patients were administered a battery of outcome measures assessing eating disorders symptoms, attitudes toward food, body dissatisfaction, level of anxiety, motivation for change, level of assertiveness and general psychiatric symptoms.

In summary, the preliminary results show that the virtual simulation of demanding real life situations is useful to improve patient's awareness, body satisfaction, eating control, social skills, self-esteem, and motivation to change. In particular, pre-treatment/post-treatment comparison seems to indicate that Integrated Experiential Therapy is more effective than traditional approaches in the treatment of Obesity and Binge Eating Disorder. Complete results will be presented in the conference.

This research is part of the Prof. Giuseppe Riva's NEUROTIV project - Immersive virtual telepresence managed care for the assessment and rehabilitation in neuro-psychology and clinical psychology.

Contact:
Gian Luca Cesa M.S.
Applied Technology for Neuro-Psychology Lab
P.O. BOX 18211
28921 Verbania, Italy
Tel. +39/0323/514278- .339
Fax. +39/0323/514338
Email: gluca.cesa@auxologico.it

Presenter: Sophie Côté, Ph.D. candidate

COGNITIVE MECHANISMS UNDERLYING VIRTUAL REALITY EXPOSURE'S EFFICACY IN THE TREATMENT OF ARACHNOPHOBIA

Sophie Côté[1], Ph.D. candidate & Stéphane Bouchard[1,2], Ph.D.

[1] Ottawa University, Ottawa, Ontario, Canada
[2] University of Quebec in Outaouais, Gatineau, Quebec, Canada

Research status: Completed.

Virtual exposure therapy for phobias is a growing field of interest. Studies have begun to demonstrate its efficacy, which is at least equivalent to in vivo exposure. However, though a majority of studies have addressed efficacy itself, few have attempted to understand the treatment mechanisms underlying this efficacy. In the case of traditional therapy, two models are still the object of a strong debate: the information processing model and the perceived self-efficacy model. Interestingly, this debate is still fuelled by their authors' attempts to prove the predictive superiority of their model by using predicted variables that are in fact different. Actually,

no study has yet directly compared the most likely predictors of change, for virtual exposure.

The goal of this study was to contrast the predictive value of different treatment mechanisms for specific phobias. The hypotheses are the following. Changes in information processing (measured with a pictorial Stroop task) will better predict changes in anxiety during a behavioral avoidance test, while changes in perceived self-efficacy will better predict changes in avoidance behaviors during a behavioral avoidance test.

Twenty-eight adult arachnophobics were assessed for standardized inclusion and exclusion criteria. General outcome and specific processes measures included questionnaires and a pictorial Stroop task. The main outcome and predicted variables were based on a behavioral avoidance test (BAT). Avoidance behavior was measured by participants' capacity to approach a live tarantula during the BAT and anxiety was measured by recording their heart rate during the first minute of the task. All measures were completed before treatment (session 1) and at post-treatment (session 7). After explanations about the cognitive-behavioral rationale for phobias and an initiation to the virtual reality equipment (session 2), participants went through virtual exposure for five sessions (60 minutes each) in various virtual environments with spiders.

Repeated measures ANOVAs on outcome measures revealed that therapy had a positive impact. Analyses made on the pictorial Stroop task showed that information processing of spider-related stimuli is faster after treatment, which also indicates therapeutic success. Psychophysiological data also showed a positive change after treatment, suggesting a decrease in anxiety. In themselves, these results represent new contributions to the field. Hierarchic regressions were about to be made as this abstract was submitted; results will be available in the presentation. These regressions will be used to assess the respective predictive capacities of each key variable for therapeutic change.

This innovative study brings fascinating information about the various and deep impacts of VRE at physiological, information processing and cognitive levels. Therefore, VRE does provoke significant clinical and statistical therapeutic change for people suffering from arachnophobia. It also brings elements of a better understanding of the distinct contribution of each predictive variable in the psychopathological models for phobias. Interestingly, this information can be applied to both in vivo and virtual reality exposure. Likewise, both clinicians and researchers can benefit from that knowledge, in order to better choose the exposure treatment targets or procedures, according to the type of changes they want to observe in clients.

References

Constantine, R., McNally, R.J., & Hornig, C.D. (2001). Snake fear and the pictorial emotional Stroop paradigm. Cognitive Therapy and Research, 25(6), 757-764.
Foa, E.B. & McNally, R.J. (1986). Mechanisms of change in exposure therapy, dans R. M. Rapee (Eds), Current controversies in the anxiety disorders, (pp. 329-343). New York : Guilford Press.
Riva, G., Wiederhold, B.K., & Molinari, (1998). Virtual environments in clinical psychology and neuroscience: Methods and techniques in advanced patient-therapist interaction. Washington: IOS Press.
Williams, S.L. (1996). Therapeutic changes in phobic behavior are mediated by changes in perceived self-efficacy. In R. M. Rapee (Eds), Current controversies in the anxiety disorders, (pp. 344-368). New York : Guilford Press.

Contact:
Sophie Côté
Ottawa University, Ottawa
Ontario, Canada
Phone : (819)_76-8045
Fax : (819) 776-8098
Email : scote067@uottawa.ca

Presenter: David Coyle MSc

ADAPTABLE COMPUTER GAMING FOR ADOLESCENT PSYCHOTHERAPY

David Coyle, MSc[1], Dr John Sharry[2], Dr Gavin Doherty[1]

[1] Trinity College Dublin, Ireland
[2] Mater Hospital, Dublin Ireland

Research Status: The Virtually Healthy Project is exploring the use of computer gaming

on adolescent mental health care. Details are given of preliminary clinical trials of a custom developed game and of ongoing research directions.

Reports show that, although mental health problems increase during adolescence, the majority of disturbed adolescents do not receive professional mental health care and of those who do fewer still fully engage with the therapeutic process (Offer et al. 1991; US Surgeon General 1999). Adolescents are generally more private and self-conscious than either younger children or adults. Typically therapy is imposed upon them (usually by their parents) and because of this they are less willing to accept it. Play therapists often engage younger children using materials such as puppets, storybooks, and construction materials. Adolescents can be resistant to these methods, not liking to be treated as children. Equally, many react confrontationally or not at all to direct dialogue (Sharry 2004). However adolescents often show a great interest in computer games. A recent UK survey reported that 53% of eleven to fourteen year olds play games four times a week or more (McFarlane et al. 2002). Computer games currently constitute a client-centred approach to adolescent psychotherapy.

Personal Investigator (PI) is a 3D computer game specifically designed to help adolescents with mental health problems. It incorporates a goal-oriented, strengths based model of psychotherapy called Solution Focused Therapy (SFT). Adolescents play the role of a personal investigator hunting for the clues that will help them solve personal problems. By engaging adolescents, in a client-centred way, it aims to build stronger therapeutic relationships between therapists and adolescents. PI is the first game to integrate this estalished psychotherapy approach into an engaging 3D game. PI differs from previous therapeutic games by encouraging the adolescent to create a written record of their own discoveries. The player creates a virtual detective notebook in which they write down all their goals, objectives, ideas, and thoughts. Upon completing the game, they receive a printout of their notebook. Clark et al. 1984 reported benefits of having a tangible output from a game. A pilot study of the game has been conducted with four adolescents, referred to clinics for issues including anxiety and behaviour problems, attempted suicide, and social skills difficulties. Initial results indicate that playing PI in sessions is very helpful in engaging adolescents. It can increase the amount of dialogue between therapists and adolescents and help in setting therapeutic goals. The use of 3D had an empowering effect, allowing the adolescent more control over the pacing and direction of the therapeutic process. For full details of the theoretical foundations, design, and pilot study of PI see Coyle et al. 2005.

PI implemented a therapeutic model in an open manner, not tailored to address specific mental health issues or specific adolescent cases. One ongoing aim of the Virtually Healthy project is to create a toolkit that allows non-programming, professional therapists to adapt and create issue specific computer games. The system should be usable by therapists with wide-ranging levels of computer literacy and be adaptable on many levels, from small fine-tuning of existing games to the creation of new games.

References

Clark, B. and Schoech, D. (1984) 'A Computer-assisted Therapeutic Game for Adolescents: Initial development and comments.' In Schwartz, M. D., *Using computers in clinical practice: Psychotherapy and mental health applications.* New York:, Haworth Press: pp. 335-353.

Coyle, D., Matthews, M., Sharry, J., Nisbet, A. and Doherty, G. (2005) 'Personal Investigator: A Therapeutic 3D Game for Adolescent Psychotherapy'. *International Journal of Interactive Technology and Smart Education* In press.

McFarlane, A., Sparrowhawk, A. and Heald, Y. (2002). Report on Educational Use of Games. Teachers Evaluating Educational Multimedia Report., TEEM.

Offer, D., Howard, K. I., Schonert, K. A. and Ostrov, E. (1991) 'To whom do adolescents turn for help? Differences between disturbed and nondisturbed adolescents'. *Journal of the American Academy of Child and Adolescent Psychiatry* 30(4): 623-630.

Sharry, J. (2004) 'Counselling Children, Adolescents and Families'. London, Sage.

US Surgeon General (1999). Mental Health: A Report of the Surgeon General. Washington, DC, US Department of Health and Human Services.

Contact:

David Coyle
Trinity College Dublin, Ireland
Tel: 353-86-8269863
Email: david.coyle@gmail.com

Presenter: Gábor Csukly MD

FACIAL EXPRESSION RECOGNITION IN PSYCHIATRIC DISORDERS USING ANIMATED 3D EMOTIONAL FACIAL EXPRESSIONS

Lajos Simon PhD[1], Gábor Csukly MD[1], Barnabás Takács PhD[2]

[1] Semmelweis University, Psychiatric and Psychoterapic Departement
[2] DigitalElite Inc.

Research Status: Completed.

The first purpose of our investigation is to create a screening protocol where repeatable and parametric facial stimuli are presented interactively to patients in order to characterize and later identify their respective mental disorders using their measured responses.

We would like to prove that depressed patients may be differentiated based on the degradation in performance of recognition.

We have generated 24 faces (12 male – 12 female) expressing the 6 basic emotions in two different ways (shown below), and 2 neutral faces (1 male – 1 female). We have shown these faces to 117 people. We have accepted a picture if the recognition rate was higher than 70%. Finally we have chosen the best recognized picture of each emotion and used these 7 pictures in the experiment. In our experiments we evaluated 26 depressed patients and used frontal views of the two 3D animated faces and asked the subjects to identify the emotion. We generated the 20-40-60-80-100% (expression level of the emotions) sequence of each validated face (5x7=35 pictures).

ANOVA evaluation of the data shows that depressed patients consistently did not show differentiable degradation in overall performance when compared to the control group. Furthermore we found that the higher the level of education the more significantly higher the recognition rate. We have found significant difference between depressed and control group points in the recognition of sadness at 100% of expression and in the recognition of happiness at 60% of expression. In each case depressed patients reached higher rates.

Contact:
Gábor Csukly MD
Semmelweis University
Psychiatric and Psychoterapic Departement
Budapest, Hungary
Tel: 36302886737
Email: csugab@yahoo.com

Presenter: Carlos de las Cuevas MD PhD

TELEPSYCHIATRY: PSYCHIATRIC CONSULTATION THROUGH VIDEO-CONFERENCE CLINICAL RESULTS

Carlos de las Cuevas MD PhD

University of La Laguna

Telepsychiatry can be conceived as an integrated system of mental health care delivery that employs telecommunications and computerized information technology as an alternative to face-to-face conventional alternative. Videoconferencing is the central technology currently used in telepsychiatry, since it permits live, two-way interactive, full-colour, video, audio, and data communication. The effectiveness of a telepsychiatry service through videoconferencing was evaluated from a users' perspective. Ninety (30 male, 60 female) subjects completed the Symptom Rating Checklist-90-Revised (SCL-90-R) on three occasions, once before the first teleconsultation and twice during telepsychiatry treatment. Patients and psychiatrist completed the Clinical Global Impression Scale-Severity Index (CGI) after each teleconsultation. Twenty five percent of patients were aged less than 30 years, 44% were aged between 30 and 45 years, 24% between 45 and 60 years, while 7% were aged over 60 years. Anxiety disorders were the more prevalent diagnosis (43.8%), followed by depression (36%), schizophrenia (7.9%), substance disorders (6.1%), and personality disorders (5.6%). The patients' mean SCL-90-R scores decreased significantly over time, indicating less psychiatric distress. Both patients and psychiatrist reported patient clinical significant improvement over time as assessed by the CGI. The mean number of

teleconsultations in patients discharged was 6. Telepsychiatry showed to be an effective mean of delivering mental health services to populations living in remote areas with limited resources.

Contact:
Carlos de las Cuevas MD PhD
University of La Laguna
Urbanización Las Cañas 33
La Laguna, Tenerife
Canary Islands 38208, Spain
Phone: 0034609521405
Email: ccuevas@ull.es

Presenter: Carlos de las Cuevas MD PhD

TELEPSYCHIATRY: PSYCHIATRIC CONSULTATION THROUGH VIDEO-CONFERENCE PATIENTS' PERCEPTION AND SATISFACTION

Carlos de las Cuevas MD PhD

University of La Laguna

A telepsychiatry service, using a videoconferencing system, was established to provide psychiatric consultations for the population of La Gomera, in the Canary Islands. During the first year of routine operation, a total of 90 patients had 90 initial and 224 follow-up teleconsultations. The main reason for the consultation identified in the general practitioner's referral form was to establish a diagnosis (70% of patients); the second most common reason was the management of a previously diagnosed patient (20% of patients). According to the results of a questionnaire survey, patients' acceptance of and satisfaction with the technology was very high. In their first teleconsultation, about a third of them said that they experienced some initial inconvenience, but this disappeared after a few minutes. During the teleconsultations, 90% of patients felt understood and could explain all their worries and fears. Ninety percent of the patients considered that they received the follow-up care they required and felt satisfied with the attention received. Only nine out of ninety patients (10%) stated they liked the 'real' doctor better than the 'television doctor'; forty five (50%) said they had no preference, and thirty five (40%) expressed their preference to telepsychiatry.

Contact:
Carlos de las Cuevas MD PhD
University of La Laguna
Urbanización Las Cañas 33
La Laguna, Tenerife
Canary Islands 38208, Spain
Phone: 0034609521405
Email: ccuevas@ull.es

Presenter: JoAnn Difede PhD

VIRTUAL REALITY THERAPY FOR POSTTRAUMATIC STRESS DISORDER FOLLOWING SEPTEMBER 11, 2001

JoAnn Difede PhD[1], Hunter Hoffman, Ph.D, Judith Cukor, Ph.D., Ivy Patt, Ph.D., Cezar Giosan, Ph.D.

[1] Weill Medical College of Cornell University

Research status: This abstract presents the findings of an ongoing study which includes, to date, 21 subjects.

Background/Problem

Posttraumatic Stress Disorder (PTSD) is a prevalent and often persistent mental illness which affects approximately 7.8% of the U.S. population.[1] In the aftermath of the World Trade Center attacks, studies of residents of New York City have found increased rates of PTSD,[2] with rates among disaster workers possibly higher. Expert treatment guidelines for PTSD recommend cognitive-behavioral treatment with exposure therapy.[3] However, due to avoidance symptoms inherent in PTSD, some patients refuse to or are unable to engage their emotions in treatment, thereby limiting its efficacy. The use of virtual reality (VR) provides a greater possibility of generating patient involvement through the multiplicity of sensory cues that it affords. The goal of this study is to evaluate the efficacy of the use of VR in the treatment of PTSD directly resulting from the World Trade Center attacks on September 11, 2001.

Method/Tools

Enrolled subjects meet diagnostic criteria for PTSD and directly witnessed at least part of the attacks of September 11th. Subjects in the treatment group receive treatment based upon a 14 –week protocol that incorporates

exposure using virtual reality with other cognitive-behavioral techniques. The subject views scenes of the World Trade Center attacks through a 3-D headset that progress in severity culminating in two planes hitting the towers and their subsequent collapses, with accompanying sounds of screaming and sirens. Subjects complete self-report questionnaires weekly and are assessed prior to and following the treatment by an experienced clinician. Subjects in the waitlist control are evaluated at baseline and again after 14 weeks, at which time they are offered treatment.

Results

To date, 7 subjects have completed the treatment protocol and 14 have been enrolled in the waitlist condition. This sample was 91% male with a mean age of 43 (SD=9). Notably, in the treatment group 5 of the 7 subjects were disaster workers and 6 of the 7 subjects had failed to respond to imaginal exposure therapy (i.e., had been in prior treatment for their PTSD symptoms but still suffered significantly from PTSD with a mean baseline CAPS score of 78 +/- 24). Data analysis shows that scores on the CAPS decreased by an average of 28 points for individuals in the VR group and decreased by an average of 5 points for individuals in the waitlist control ($p<.05$).

Conclusion

This preliminary data suggests that virtual reality is an effective treatment for PTSD. Novelty/Discussion: This preliminary study is the first to show that virtual reality is an efficacious treatment for individuals suffering from PTSD following terrorism and, to our knowledge, is only the second study of PTSD using virtual reality. Treatment failures using imaginal exposure may be partially due to the inability of the patient to emotionally engage in the exposure work. Virtual reality appears to address this problem by enhancing the patient's capacities with visual, auditory, and even haptic computer-generated experiences, thereby facilitating the patient's emotional engagement in the exposure treatment.

References

1. Kessler RC, Sonnega A, Bromet E, Hughes M, Nelson CB:
Posttraumatic stress disorder in the national comorbidity survey.
Archives of General Psychiatry, 52: 1048-1060, 1995.

2. DeLisi LE, Maurizio A, Yost M, et al. A survey of New Yorkers after the September 11, 2001, terrorist attacks. American Journal of Psychiatry. 2003;160:780-783.

3. Foa EB, Davidson RT, & Frances A. (eds.) Expert Consensus Guideline Series: Treatment of posttraumatic stress disorder. Journal of Clinical Psychiatry, 60: 5-76, 1999.Contact:
JoAnn Difede, Ph.D.
Weill Medical College of Cornell University
525 East 68th St Box 200
New York, NY 10021
Phone: 212-746-3079
Fax: 212-746-0719
Email: jdifede@med.cornell.edu

Presenter: Mario Doulis

THE AMALGAMATION - PRODUCT DESIGN ASPECTS FOR THE DEVELOPMENT OF IMMERSIVE VIRTUAL ENVIRONMENTS

Professor Mario Doulis, Andreas Simon

University of Applied Sciences Aargau, CH

Interacting in an immersive virtual environment we refer to the real world. The user gets to expect real world behaviour from virtual objects and functions. We explore the idea of bringing aspects of product design to the development of input devices and interaction techniques for virtual environments. We use ergonomics and *product language* to design the physical input device, the virtual representation and the connection between real and virtual parts. This connection, which we call *amalgamation*, is the most important element of the design, since it defines, if the user rather interacts with virtual objects as "virtual products" (via an input device), or rather interacts with an input device as a "real product" controlling virtual content.

Contact:
Mario Doulis
University of Applied Sciences Aargau, CH
Email: m.doulis@fh-aargau.ch

Presenter: Stéphanie Dumoulin

POTENTIAL MECHANISMS UNDERLYING THE EFFICACY OF VR TO REDUCE ACUTE PAIN: A LITERATURE REVIEW

Stéphanie Dumoulin, B.Sc., Stéphane Bouchard, Ph.D. & Vicky Rivard, Ph.D.

Cyberpsychology Lab of the University of Quebec in Outaouais

Research status: Completed.

Pain is now considered a complex subjective phenomenon that involves sensorial, motivational, cognitive, and emotional dimensions. Recent studies have now shown that virtual reality (VR) can be used to control and reduce acute pain; probably because of it's potential for distracting attention away from the pain. But many factors may influence the efficacy of VR to help manage pain. The aim of this literature review is to summarize the studies that assessed the efficacy of VR in experimental and clinical pain management in order to highlight psychological variables that may be involved in the mechanisms of pain management using VR.

Method

This systematic review followed a standard and structured research approach. It has the advantages of being rigorous, replicable, and the results can easily be presented in a poster format. Journal databases such as *MedLine, PsycINFO* and *Web of Science* were searched with key words such as «pain» or «pain management» were crossed with key words such as «virtual» or «virtual reality». More than 110 articles were found. Most of them were theoretical. But 17 empirical studies using VR to manage pain were found. Six used rigorous experimental protocols and 11 were more exploratory and had no experimental protocol.

Results and Conclusion

Most studies showed an important and statistically significant reduction in pain. Although distraction is considered the key ingredient to explain theses results, a detailed analysis reveals that several factors might be involved. These factors could be grouped in three categories: task relevant (e.g., attention required, task complexity, and emotional content), individual (e.g., sense of presence, hypnotisability, self-efficacy, and outcome expectations) and pain factors (e.g., pain intensity). We believe that by highlighting explicitly in this poster the variables that may lead to pain management, VR researchers can narrow more effectively their search for treatment moderators and mediators.

Contact:
Stephanie Dumoulin, B.Sc.
tifdum@hotmail.com
Phone: (819) 771-7761-8419
Fax: (819) 776-8098

Presenter: Natalia Fernández

MOTIVATIONAL TRAINING TOOL TO PROMOTE HEALTHY LIFESTYLE USING VIRTUAL REALITY

Natalia Fernández, PhD candidate

Universidad Politecnica de Madrid

One of the main challenges that developed societies face is the prevention of non-communicable diseases such as diabetes or obesity. These diseases are responsible for 60% of the registered global deaths and for 45% of the global burden of disease. Unhealthy diet, together with physical inactivity and smoking, are among the key risk factors for the development of these illnesses. The fact that these are preventable leads directly to the elaboration of prevention strategies that aim to empower and motivate the citizens to be responsible for their own health by, among others, providing them with quality and personalised information. As the purpose is to incorporate healthy lifestyles to the users' daily activities, motivational aspects need to be seriously taken into account. Hence, the way the information is presented to the user must be carefully analysed.

The development of a virtual reality tool helps to motivate the user and also improves the e-learning process. The work presented in this paper contributes partially to solve this situation by offering the users personalised information for their own self-care and furthermore, by motivating them to make use of this information and take control of their decisions regarding their lifestyle through the use of a virtual reality tool.
The tool, based in X3D (eXtensible 3D), a

virtual 3D technology for the Internet, is integrated in an e-learning environment which is also interactive and immersive. A training activity in the system consists of an Internet multimedia session that shows personalised information by means of an attractive visual interface. It is worth mentioning that the tool not only provides citizens specific information adapted to their profile and needs but also the interface is personalised accordingly. The information managed throughout the system, including the virtual scenarios, has been stored using the XML format.

Moreover, in order to perform the personalisation of the tool for every single user, the system has been programmed to be "intelligent." The process is started by obtaining the user profile. This is created the first time the citizen accesses the tool by filling in a structured questionnaire about nutritional, statistical, motivational and physical activity data. By processing this data, the information that suits the user needs and preferences best, is selected from a native XML database. In addition, the information is presented to the users in a different way depending on their motivational state, which is revealed by applying the "Stages of Change" methodology.

In order to measure the user response to the system, a survey is compiled after the first training session. The evaluation of the results allows us to conclude that Virtual Reality is perceived as an interesting and easy to use tool. Besides, the users state that the relation between the scenarios developed and the information provided in each of them was tailored to their needs and the contents were marked as a good educational tool to adopt a healthy lifestyle.

Contact:
Natalia Fernández
E.T.S.I.Telecomunicación.
Ciudad Universitaria
Universidad Politecnica de Madrid
Phone: +34 91 549 57 00 ext. 332
Fax: +34 91 336 68 28
Email: nfernandez@gbt.tfo.upm.es

Presenter: Marta Ferrer-Garcia

ASSESSMENT OF EMOTIONAL REACTIVITY PRODUCED BY EXPOSURE TO VIRTUAL ENVIRONMENTS IN PATIENTS WITH EATING DISORDER

José Gutiérrez-Maldonado, PhD , Marta Ferrer-Garcia, PhD candidate

University of Barcelona, Spain

This paper describes the effectiveness of virtual environments to elicit emotional responses in eating disordered patients. This study is part of a wider research project analysing the influence of the situation to which subjects are exposed on their performance on body image estimation tasks.

Though it seems self-evident that there is a close relation between eating disorders (ED) and altered body image, in the literature on the subject no clear association has in fact been established, and indeed the results of the studies[1, 2, 3, 4, 5] are often contradictory or inconclusive. A number of hypotheses have been proposed to account for these results. Some authors have stressed the fact that body image may be to a certain extent more a state than a trait[2, 4, 8] and may change according to situational or emotional variables. Several studies have analysed the possible impact of exposure to specific objects or situations on the stability of the body image.[6,7, 8, 9, 10, 11]

In this study we designed several virtual environments that were emotionally significant for subjects with ED in order to generate different levels of anxiety and variations in mood. Unlike conventional methods (real exposure to the situation, exposure to photographs, exposure via guided imagination, and so on), virtual reality exposes subjects to interactive three-dimensional environments that simulate real situation. These environments have ecological validity but also permit strict control over the variables and the recording of data. Virtual reality offers many of the advantages of the conventional methods mentioned above, and also overcomes many of their drawbacks.

Thirty female patients with eating disorders were exposed to six virtual environments: a living-room (neutral situation), a kitchen with high-calorie food, a kitchen with low-calorie food, a restaurant with high-calorie food, a restaurant with low-calorie food, and a swimming-pool. After exposure to each environment the STAI-S (a measurement of state

anxiety) and the CDB (a measurement of depression) were administered to all subjects.

The results showed significantly higher levels of state anxiety in the kitchen with high-calorie food (F=13.120; p = 0.001), the restaurant with high-calorie food (F = 14.954; p = 0.001) and the swimming-pool (F = 4.230; p = 0.049) than in the neutral environment. Analysing the scores for depression obtained on the CDB, significant differences again appeared between the high-calorie food environments (F = 7.187; p = 0.012 in the kitchen and F = 5.933; p = 0.021 in the restaurant) and the neutral environment. In the high-calorie food situations patients with ED showed a more depressed mood.

Virtual reality thus appears to be a valid instrument particularly useful for simulating everyday situations that may provoke emotional reactions such as anxiety and depression, in patients with ED. Virtual environments in which subjects are obliged to ingest high-calorie food provoke the highest levels of state anxiety and depression. Previous studies have shown the capacity of VR to elicit states of anxiety in patients with other pathologies too.[12, 13, 14]

References

1. Hsu, L.K.G. & Sobkiewick, T.A. (1991). Body image disturbance: Time to abandon de concept for eating disorders? *International Journal of Eating Disorders,* 10 (1), 15-30.
2. Slade, P.D. & Brodie, D. (1994). Body Image distortion and eating disorder: A reconceptualitation based on recent literature. *Eating Disorders Review,* 1 (2), 32-46.
3. Cash, T.F. & Deagle, E.A. (1997). The nature and extend of body image disturbances in anorexia nervosa anb bulimia nervosa: a Meta-analysis. *International Journal of Eating Disorders,* 22, 107-125.
4. Sepúlveda, A.R.; Botella, J. & León, J.K. (2001). La alteración de la imagen corporal en los trastornos de la alimentación: un meta-análisis. *Psicothema,* 13 (1), 7-16.
5. Skrzypek, S.; Wehmeier, P.M. & Remschmidt, H. (2001). Body image assessment using body size estimation in recent studies on anorexia nervosa. A brief review. *European Child & Adolescent Psychiatry,* 10, 215-221.
6. McKenzie, S.J.; Williamson, D.A. & Cubic, B.A. (1993). Stable and reactive body image disturbances in bulimia nervosa. *Behavior Therapy*, 24, 195-207.
7. Carter F.A., Bullick C.M., Lawson R.H., Sullivan P.F. & Wilson J.S. (1996). Effect of mood and food cues on body image in women with bulimia and controls. *International journal of eating disorders,* 20 (1), 65-76.
8. Cash, T.F.; Cash, D.W. & Butters, J.W. (1983). "Mirror, mirror, on the wall...?": Contrast effects and self-evaluations of physical attractiveness. *Personality and Social Psychology Bulletin,* 9 (3), 351-358.
9. Heilbrun, A.B. & Flodin, A. (1989). Food cues and perceptual distortion of the female body: implications for food avoidance in the early dynamics of anorexia nervosa. *Journal of Clinical Psychology,* 45 (6), 843-851.
10. Laberg, J.C.; Wilson G.T.; Eldredge K. & Nordby H. (1991). Effects of Mood on Heart Rate Reactivity in Bulimia Nervosa. *International Journal of Eating Disorders,* 10 (2), 169-178.
11. Haimovitz D.; Lansky L.M. & O'Reilly P. (1993). Fluctuations in body satisfaction across situations. *International Journal of Eating Disorders,* 3 (1), 77-84.
12. James, L.K., Lin, C. –Y., Steed, A., Swapp, D. & Slater, M. (2003). Social anxiety in virtual environments: Results of a pilot study. *CyberPsychology & Behavior,* 6 (3), 237-243.
13. Robillard, G., Bouchard, S., Fournier, T. & Renaud, P. (2003). Anxiety and presence durent virtual reality immersion: A comparative study of the reactions of phobic and non-phobic participans in therapeutic virtual environments derived from computer games. *CyberPsychology & Behavior,* 6 (5), 467-476.
Pertaud, D.P., Slater, M. & Baker, C. (2001). An experiment on public speaking anxiety in reponse to three different types of virtual audiences. *Presence: Tele-operators and Virtual Environments,* 11, 68-78.

Contact:
Marta Ferrer-Garcia
Departamento de Personalidad, Evaluación y Tratamientos Psicológicos
Facultad de Psicología. Paseo Valle de Hebron, 171, 08035 Barcelona, Spain
telephone number: +34933125126
fax number: +34934021362
e-mail : martaferrerg@ub.edu

Presenter: Raymond A. Folen PhD

IS VIRTUAL REALITY BETTER THAN NON-VIRTUAL REALITY CLINICAL

APPLICATIONS? A DISCUSSION OF FIVE STUDIES

Raymond A. Folen, Ph.D.

Tripler Army Medical Center, Department of Psychology

Research Status: In Progress

Background/Problem

Virtual Reality (VR) interventions for behavioral health have demonstrated promise for a wide variety of clinical concerns.[1] At the same time, most research to date has lacked control conditions and comparisons with non-VR environments and interventions,[2] making it more challenging to justify the cost of establishing in-house VR services. Research being conducted at the Pacific Telehealth & Technology Hui Virtual Reality Behavioral Health laboratory compares VR interventions with active treatment controls and standard of care controls, and assesses the efficacy of different display formats. Five controlled comparison study protocols designed to advance the field of VR in behavioral health will be presented and preliminary findings will be discussed.

Method

Two of the research projects, a reactivity to anger stimuli study and a nicotine cue exposure study, evaluate the effectiveness of immersive panoramic video virtual environment (VE) displays in evoking physiological and emotional responses to anger stimuli or smoking cues compared to flat screen video displays of the same content. Outcome measures include standardized questionnaires and physiological measures of heart rate, blood pressure, skin conductance, temperature, and respiration. The third study, a biofeedback training study, compares the effectiveness of three biofeedback training modalities for controlling peripheral body temperature. Participants are randomly assigned to one of three training conditions: (1) temperature change presented on a monitor (standard feedback mode), (2) standard feedback presented through a HMD, and (3) immersive VE with pictorial feedback display presented through a HMD. Outcome measures include the maximum temperature difference, time to maximum temperature, time to criterion temperature, duration of criterion temperature, and rate of change. Chronic pain is the focus of the fourth study which compares the effectiveness of three treatment conditions in reducing the perception of chronic pain: (1) therapist guided imagery (standard treatment), (2) audio-taped imagery, and (3) therapist guided imagery enhanced with VR. The outcome measures consist of pre- and post- treatment pain perception, self-efficacy ratings of treatment effectiveness, and physiological measures. The fifth study compares the effectiveness of VR as a pain and anxiety distraction to the standard of care for participants undergoing a cystoscopy examination. Outcome measures include the degree of perceived pain, pre- and post-procedure anxiety, and physiological measures.

Results, Conclusions, and Novelty: The five studies will be discussed in terms of protocol design and anticipated unique contributions to the field of VR in behavioural health. Several themes will be highlighted, including (1) the need to establish the incremental benefit of using VR versus alternative display formats, such as in the anger reactivity, nicotine and biofeedback studies, (2) the need for controlled comparisons as exemplified by all of the studies, (3) the need to generalize findings within clinical domains, e.g., generalizing pain analgesia findings for cystoscopy examinations, and (4) the benefits of establishing experimental results that may be transportable to clinical applications, such as the use of VR-enhanced thermal biofeedback training for reducing migraine headaches or anger reactivity study protocols for anger management programs. Preliminary standardized questionnaire and physiological findings will also be presented.

References

1 Wiederhold, B. K. (2000). Virtual reality in the 1990's: What did we learn? CyberPsychology & Behavior, 3:311-314.

2 Miyahira, S. D., Folen, R. A., & Mezo, P. G. (2005, January). Use of virtual reality environments and VR technology in behavioral health: Is the bang worth the bucks? Poster session presented at the 13th annual meeting of the Medicine Meets Virtual Reality Conference, Long Beach, CA.

Contact:
Raymond A. Folen, Ph.D.
Tripler Army Medical Center
Department of Psychology

1 Jarrett White Road
Honolulu, Hawaii 96859-5000
Phone: 1-808-433-5865
Fax: 1-808-433-1466
Email: raymond.folen@amedd.army.mil

Presenter: Beau J. Freund PhD

PHYSIOLOGIC MONITORING OF SOLDIERS: PRESENT AND FUTURE

Beau J. Freund, Mark J. Buller, William A. Latzka and Karl E. Friedl

U.S. Army Research Institute of Environmental Medicine

Wearable medical sensors can provide real time situational awareness to the soldier, commander, and medic. Key to this system is the algorithms and knowledge displays that link and interprets sensor information. For the first time ever, the U.S. Army has a prototype system that will monitor physiological signals from the soldier and integrate this sensor data through algorithms to predict health status. This Warfighter Physiological Status Monitor-Initial Capability (WPSM-IC) is comprised of a medical hub that hosts a personal area network of physiologic and medical sensors (heart rate, respiration, skin and core temperature, body motion, acoustic/impact, sleep history, fluid intake) and algorithms. The algorithms estimate thermal, hydration, cognitive, life signs, and wounding status from the sensors distributed around a soldier's body, uniform and equipment and from other models, databases, and contextual information (e.g., location, weather, mission, individual data). This system is intended as one component of future warrior system of systems with differential displays of the information to the individual, the unit leader, and the medic, ranging from aggregate data on overall status members of the unit for the leader to specific early triage of a wounded soldier for the medic. This physiological monitoring capability lays the groundwork for data collection for further refinements, as well as testing a wide range of potential useful applications. Further research with this system will expand understanding of limits on human tolerance. Applications may include safety monitoring in hazardous conditions, training to learn and teach soldier limits, closed loop systems for control of equipment (e.g., microclimate cooling, exoskeleton, information displays), and as sentinel soldier surveillance systems. This system also provides the backbone for future neurocognitive monitoring enhancements. These may draw from currently available sensors such as voice analysis, pupil responses, saccadic eye movements, slow eyelid closure, electroencephalography, non-invasive biochemical measures (e.g., tear analytes), and nerve conduction velocity. The challenge will be the research studies in realistic and stressful conditions that lead to development of valid predictive algorithms of brain function and behavior. These predictions of the consequences of information overload, psychological trauma, and physiological stress consequences to brain function will be central to future adaptive displays.

Contact:
Beau J. Freund
U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760

Presenter: Andrea Gaggioli PhD

THE VIRTUAL REALITY MIRROR: MENTAL PRACTICE WITH AUGMENTED REALITY FOR POST-STROKE REHABILITATION

Andrea Gaggioli[1]; Francesca Morganti[1]; Andrea Meneghini[2]; Mariano Alcaniz[3]; José Antonio Lozano[3]; Javier Montesa[3], José Miguel Martínez Sáez[3]; Richard Walker[4]; Irene Lorusso[4], Giuseppe Riva[1].

[1] Applied Technology for Neuro-Psychology Lab,

Istituto Auxologico Italiano, Milan, Italy

[2] Azienda Ospedaliera dell'Università di Padova, Unità Operativa di Riabilitazione, Italy
[3] MedICLab, Universidad Politecnica of Valencia, Spain
[4] Telecom Italia Learning Services, Rome, Italy

Research status: in progress

The aim of the project is to apply augmented-reality technology to teach motor skills to patients suffering from stroke. To achieve this goal the project adopts an innovative approach based on the use of so-called "motor imagery." Recent studies in neuroscience have provided converging evidence that "imagining" a motor action involves the same brain areas involved in performing the ac-

tion.[1] This supports the idea – already exploited by sports trainers – that training with motor imagery (mental practice) could be effective in learning new motor skills or in promoting motor recovery after damage to the central nervous system. Previous clinical studies have shown that the rehabilitation of post-stroke hemiplegic patients can be made more effective by combining physical practice with mental practice.[2,3] However, for many patients who suffer from damage to the central nervous system, mental simulation of movements can be difficult, even when the relevant neural circuitry has not been injured. Starting from these premises, we have designed and developed an augmented-reality workbench (called "VR Mirror") to help post-stroke hemiplegic patients evoking motor images. First, the movement is acquired by the system from the healthy arm. Second, the movement is being mirrored and displayed so that the patient can observe and see as if the impaired arm is performing the movement. Third, the patient is instructed to rehearse in his/her imagination the movement he/she has just observed. Last, the patient has to perform the movement with the affected arm. The system is currently being tested to see if it does help patients to recover more quickly and regain control of arms that have been paralysed following a stroke. Preliminar clinical outcomes will be presented during the conference. The research is supported by the EU project, called I-learning (Immersion/Imagery Enhanced Learning[4]), which is funded under the FET Program (Future and Emerging Technologies[5]).

References

1. Jeannerod, M., *Neural simulation of action: a unifying mechanism for motor cognition.* Neuroimage, 2001. **14**(1 Pt 2): p. 103-9.
2. Stevens, J.A. and M.E. Stoykov, *Using motor imagery in the rehabilitation of hemiparesis.* Arch Phys Med Rehabil, 2003. **84**(7): p. 1090-2.
3. Page, S.J., et al., *A randomized efficacy and feasibility study of imagery in acute stroke.* Clin Rehabil, 2001. **15**(3): p. 233-40.
4. http://www.tils.com/i-learning/html/objectives.htm.
5. http://www.cordis.lu/ist/fet/pr2-da.htm.

Contact:
Andrea Gaggioli
Applied Technology for Neuro-Psychology Lab
Istituto Auxologico Italiano
Via Pelizza da Volpedo 41
Milan, Italy
Phone/Fax +39-02-619112892
Email: andrea.gaggioli@auxologico.it

Presenter: Enrico Gaia Dr. Ing.

VIRTUAL TECNOLOGIES FOR EXTREME ENVIROMENT EFFECT MITIGATION

Enrico Gaia Dr. Ing.

Alenia Spazio S.p.A. Torino Italy

This paper examines the demands of a manned system operating in an extreme environment where there is the need to enhance or at least maintain crew health, team spirit and cohesion and how new techniques based on Virtual Reality technologies can provide some answers. A typical example is a manned mission to Mars with a crew of 4-8 astronauts where it is mandatory to maintain their psychological health for a mission that is envisaged to last from two to three years. They will have to work and live in an artificial environment with limited resources (for example communication capability with ground, due to the distances involved, cannot be a direct two way system) and living volumes. The paper proposes some possible fields of investigation. It will also consider the fact of how these innovative technologies based on Virtual Reality will have to be developed and tested.

Contact:
Enrico Gaia
Alenia Spazio S.p.A.
Torino, Italy
Phone: +39 011 7180742
Email: Enrico.Gaia@aleniaspazio.it

Presenter: Carlo Galimberti PhD

THE DOMOTIC EVALUATION

Carlo Galimberti, Ph.D[1], Luca Menti, M.S., Simona Pegorari, M.S.

[1]Università Cattolica del Sacro Cuore-Milano

Domotic introduces remarkable advantages, above all to impaired persons, and elders, but at present the lack of an actual user-oriented design occurs. We planned and put in act an action-research, now in progress, in the framework of the "Domus" project (Tuscany Region council resolution n.977/2003) with the participation, in the first phase, of 10 couples affected by mobility disorders, each one living for five days in a domotic apartment.

The aims are to set up a methodology of analysis of the user-domotic environments interaction and to supply results concerning the interaction of an impaired user with a domotic environment, with the aim both to assess the system and to propose new solutions.

General approach

An anthropological and ethno-methodological approach was followed, in terms of an actual user-oriented design. Into details, the domotic environments design must follow an iterative procedure, foreseeing a continuous loop among design, ergonomic evaluation, and implementation. This ergonomic stance to evaluate not only technical and functional requirements (conformance testing) but also general usability and usefulness of the environment (usability evaluation), considering both the physical and the cognitive affordance.

Methodolgy

The evaluation phases foresee the analysis of autonomy project, impairments and resources, and interaction with artefacts.

Focusing on the interaction analysis we evaluated usability, efficacy, efficiency, satisfaction, usefulness, and pleasantness.

Methods and techniques were constructive interaction - thinking aloud modality, participating observation, semi-structured interview, video-recordings of all the interactions, and analysis of the reports supplied by the software controlling the electronic domotic environments.

References

Galimberti, C. et al. (2004) Cybertherapy. Internet and Virtual Reality as Assesment and Rehabilitation Tools for Clinical Psychology and Neuroscience" Amsterdam, IOS Press, 2004 - Njord-Tide Project DE4102 http:// njord-tide.arch.kth.se

Contact:
Carlo Galimberti
Dept of psychology -Università Cattolica del Sacro Cuore-Milano
Milan, Italy 20123
Phone: +39272342660
Fax: +39272342280
Email: carlo.galimberti@unicatt.it

Presenter: Carlo Galimberti PhD

BEYOND INTERFACES: AN INTEGRATED APPROACH TO THE ERGONOMIC ANALYSIS OF VIRTUAL ENVIRONMENTS IN PSYCHOTHERAPY OF ANXIETY DISORDERS

Carlo Galimberti, Ph.D[1], Gloria Belloni, M.A., Matteo Cantamesse, M.S., Fabiana Gatti, Ph.D., Maddalena Grassi, Ph.D., Luca Menti, M.S.

[1]Università Cattolica del Sacro Cuore-Milano

Research Status: In Progress (analysis of first clinical trial data)

Background/Problem

The present study is part of the FIRB-NEUROTIV project whose main objective is to develop – on the basis of the result and applications coming out from VEPSY Project, funded by EU (Galimberti et al. 2004) – the technical and clinical viability of using Virtual Reality Therapy in clinical psychology by means of portable and shared VR Systems. The project is providing enhancements of Vepsy's tools (Telemedicine and Portable tools) for the treatment of patients, new clinical trials to verify their viability, action plans for dissemination of its results to an extended audience and an integrated approach to ergonomic analysis of 3D Virtual Environments for psychotherapy.

Method/Tools

To face the aspects connected with VR environments' usability for psychotherapeutic applications mean to dare a double challenge from a methodological point of view: from one side, the need to adapt and to inte-

grate on a heuristic basis classic usability evaluation methods to specific artifacts such as 3D Virtual Environments for clinical applications (Galimberti and Belloni, 2003); from the other hand, the problems arisen by integration of expert evaluation of VR environments user-based tests carried out in real context of use (Riva, 2003; Mantovani, 2000). To face these challenges we have chosen to base our analytical stance upon an ethnometodological approach, a perspective that gives evidence of how people, in specific social situations, are able to solve complex tasks producing shared meanings and achieving their goals during interaction. According to this perspective, the methodological objective consisted also in the identification of the usability requirements of the specific *community of practice* by whom Virtual environments are to be used (Riva and Galimberti, 2001). The virtual environments considered were the Panic Disorders and Agoraphobia VR modules developed in the framework of the FIRB - NEUROTIV project.

Data had been produced by means of different situations:

- functional analysis of VR environments
- observational analysis of videotaped patient-VR environments interactions, therapist-patient interactions and therapist-patient-VR environments interactions during therapy sessions
- Semi-structured interviews to out-patients
- Usability tests performed by out-patients

Different data analysis technique (Galimberti et al., 2004; Krug, 2000), both quantitative and qualitative, are presently applied to data producted.

Novelty/Discussion

- The main goal of the study is to go 'beyond interfaces,' extending ergonomic analysis of 3D virtual environments use in psychotherapy to such topic as:
- their pragmatic context of use
- the culture of use featuring the community of professional users
- side-effects and by-products of their application
-

Obviously without forgetting the outcomes of traditional usability analysis. The research is thus intended to construct - and not of simple application –new tools for an ergonomic analysis. One of its main features will be to have not only a descriptive function, but to find out solutions to make the VEs systems more efficient. And this is intended to improve the whole interactive process, abandoning both artifact and user–artifact centered interaction in favor of a *'situated and context sensible'* ergonomic analysis.

References

Galimberti C., et al. 2004 "An Integrated Approach to the Ergonomic Analysis of VR2 in Psychotherapy: Panic Disorders, Agoraphobia and Eating Disorders in: G. Riva, C. Botella et al., *Cybertherapy*, IOS Press, Amsterdam, pp. 231-251.
Galimberti C. and Belloni G. 2003 "Three-Dimensional Virtual Environments for Cybertherapy: A Psychosocial approach to Effective Usability", in *Cyberpsychology and Behavior*, vol. 6, n.3, pp. 229-236.
Krug, S. 2000 *Don't make me think! A common sense approach to Web Usability*, Indianapolis, Macmillan
Mantovani, G. (edited by) 2000 *Ergonomia. Lavoro, sicurezza e nuove tecnologie*, Bologna, il Mulino
Nielsen, J. 2000 *Web usability*, Milano, Apogeo Riva, G. and Galimberti, C. (edited by) 2001 *Towards CyberPsychology: Mind, Cognition and Society in the Internet Age,* Amsterdam, Ios Press
G. Riva G. 2002 Web usability revised: a situated approach. *Psychnology Journal*, 1:1. Available on line: http://www.psychnology.org

Contact:
Carlo Galimberti
Dept of psychology -Università Cattolica del Sacro Cuore-Milano
Milan, Italy 20123
Phone: +39272342660
Fax: +39272342280
Email: carlo.galimberti@unicatt.it

Presenter: Luciano Gamberini, PhD

PLAYSAFETY: VIRTUAL ENVIRONMENTS AS A PERSUASIVE TOOL TO CONTRAST RISKY BEHAVIORS IN YOUTH

Adriano Purgato and Luciano Gamberini, Ph.D.

HTLab - Human Technology Laboratories, University of Padova, Italy

Research Status: Complete

This paper, following the idea of Persuasive Technology proposed by Fogg (2003), presents a way to develop a Virtual Reality (VR) educational system, Playsafety, capable of having an impact on risky behaviors in young people. The participative design of Playsafety, its application in the field and its first evaluation will be illustrated.

Background

Can Virtual Reality work as a means to prevent drug abuse and to persuade people into adopting safe behaviors? The potentials of VR as learning or health care environment have long been investigated (de Jong, 1991; McComas 2002; Riva, 2002). Virtual Environments offer the opportunity to explore social situations and 'try out' different responses to a variety of events (Kerr et al, 2002; Alcañiz M., 2003). As simulations, they also allow to cope with novel situations (Gamberini et al., 2003) and explore cause-and-effect relationships in a safe, non-threatening, and compelling environment (Fogg, 2003).

Method and Tools

A first step in the creation of *Playsafety* was an ethnographic investigation of dangerous night situations. A six-month participative observation was carried out in the clubs of a summer holiday location in Italy. The field notes were organized as *'stories about people and how they keep on their projects'* (Carroll, 2000).

In a second stage, following the scenario-based design approach (Carroll,2000), four different hazardous situations were extracted from the notes and as many VEs were built with 3D Studio Max 4.2 and Virtools DEV 2.5. Environments included a discotheque, a park, a restroom as place for drug and alcohol abuse, and a motorbike ride (safe drive). The heuristic method of expert evaluation (Nielson, 1993; Hix et al.,1993) was deployed to test their usability. Within each environment, two avatars interacted with the user. Participants were free to respond to the situation in many different ways, each one provoking a different modification in the scene.

Finally, the virtual scenarios were tested on-site, during a two sessions-evaluation in several clubs. Users were invited to judge the environment and its efficacy through a 24 items questionnaire and a short interview. The evaluation addressed persuasiveness of the artifact, presence feeling, quantity and quality of concepts learned, user's perception of consistency, effectiveness, and usefulness of the product.

Results

In general, users declared to have more competence on drug-related issues and risky behaviours after the VE experience. They declared to understand clearly what designers want to communicate with them (av. 5.50/6 points), to perceive a strong consistency between real situations and virtual worlds (av. 4.75/6 points) and to consider the VE useful to educate people on specific drug effects. Perceived usefulness of the product was particularly high in the age range 24-29 for alcohol abuse (χ^2=10.814,p=.013 with $d.f.$=4 α=.05).

Conclusion

Scenario-based-design seems to be a precious methods to develop VE educational tools for risk prevention: *Playsafety* provides a safe educational experience to young people who potentially could be involved in dangerous contexts. As a persuasive technology working on cause-effect relationships, *Playsafety*, effectively communicates what risk underlies many common situations in youth life.

Novelty

The tool addresses the lack of persuasive products regarding alcohol and safe-driving problems in young people.

References

Alcañiz M., Baños R., Botella C., Rey B. The EMMA Project: Emotions as a Determinant of Presence. Psychology Journal 1, [2]. 2003 (available on line: http:// www.psychnology.org)

Carroll J.M., Rosson M.B., *The development of cooperation: five years of participatory design in the virtual school*, Publication of the ACM, 239-251, 2000

De Jong T., *Learning and instruction with computer simulations*, Editions & Computing, 6: 217-229, 1991

Fogg B.J. *Persuasive Technology*, Morgan Kaufmann, 2003
Gamberini L., Cottone P., Spagnolli A., Varotto D., Mantovani G. (2003) *Responding to a fire emergency in a virtual Environment: different patterns of action for different situations*. Ergonomics. 46 (8) pp. 842-858
Hix D., Hartson H.R., *User Interface Development: Ensuring Usability trough Product and Software*, John Wiley and Sons, New York, 1993.
Kerr S.J., Neale H.R., Cobb S.V.G., *Virtual Environments for Social Skill Training: The important of Scaffolding in Practice*, Publication of the ACM, 104-110, 2002
McComas J., MacKay M., Pivik J., Effectiveness of Virtual Reality for Teaching Pedestrian Safety CyberPsychology & Behavior. Vol. 5, Page 185-190, 2002
Nielson J., *Usability Engineering*, Academic Press, 1993.
Riva G., Virtual Reality for Health Care: The Status of Research. CyberPsychology & Behavior. Vol.5, Page 219-225. 2002

Acknowledgements

This work was partly sponsored by Comune di Faenza within the project "Catcher in the Rye". The authors wish to thank: Dr Edoardo Polidori and all the workers of the SerT Faenza, Provincia of Ferrara and "W la Notte" project for providing a useful space to test the product, ZeroCento and RicercAzione Associations (Faenza) for helping us since the early stage. Finally we would like to thank Gianluca Borghi, Assessore alle Politiche Sociali, Regione Emilia Romagna for supporting the project.

Contact:
Luciano Gamberini, PhD
Tel: ++39/049/8276605
Fax: ++39/049/8276600
Email: luciano.gamberini@unipd.it
www.psicologia.unipd.it/htlab

Presenter: Pedro Gamito PhD

VIRTUAL WAR PTSD - A METHODOLOGICAL APPROACH

Pedro Gamito, PhD, José Pacheco; Carlos Ribeiro; Cristina Pablo; Tomaz Saraiva

Universidade Lusofona de Humanidades e Tecnologias

Exposure *in vivo* is a well tested and effective treatment in anxiety and phobic disorders. However, it is not viable to expose patients with War Post Traumatic Stress Disorder (PTSD) to real war environments. Being virtual reality exposure the most approximate simulation of a real war situation, we hypothesized that treatments of War PTSD that included virtual reality exposure are better than the current forms of psychotherapeutic intervention, namely exposure in imagination. This paper describes the procedures and presents the up to date development of (VR) war environments as a methodology to implement immersive virtual reality VR as an alternative psychotherapeutic course of action for patients with the diagnostic of War PTSD. The study population of this ongoing research consists of male subjects with the diagnostic of War PTSD according to DSM-IV-TR (APA, 2001) that looked for treatment at Júlio de Matos Hospital in Lisbon, Portugal. Participants were distributed through 6 treatments plus placebo (VR; Drug treatment; Imagination Exposure; VR+Drug Treatment; VR+Imagination Exposure; Drug Treatment+Imagination Exposure). The adequate therapeutic dosage with Sertraline (Zoloft, Pfeizer) will be administrated during 16 weeks to the Drug Treatment groups. VR Treatment groups will be using a Head Mounted Device that provides an immersive experience on the following war virtual scenarios: mine deflagration, assisting casualties, waiting for a rescue helicopter, and ambush. CAPS, BDI, STAI, SCL-90, MCM-II for Psychometric measures and TAS, DES, PQ, SUDS, heart rate and blood pressure, ECG, EEG, and ACTH for VR reactions measures are the evaluation procedures selected for assessing the results.

Contact:
Pedro Gamito, PhD
Universidade Lusofona de Humanidades e Tecnologias
Rua Prof. Barbosa Sueiro, 5 2B
1600 Lisbon Portugal
Tel: +351966057132
Email: pedro.gamito@sapo.pt

Presenter: Azucena Garcia-Palacios PhD

OUTCOME PREDICTORS IN VIRTUAL REALITY EXPOSURE FOR THE TREATMENT OF PHOBIAS

Garcia-Palacios, A. Ph.D.[1], Quero, S., Ph.D.[1], Botella, C., Ph.D.[1] & Banos, R., Ph.D.,[2]

[1] Universitat Jaume I Castellon. (Spain).
[2] Universidad de Valencia (Spain).

Virtual Reality (VR) Exposure has proven to be efficacious in the treatment of phobias. There are an increasing number of controlled studies that support the use of VR as an effective tool in the treatment of several specific phobias like acrophobia, claustrophobia, spider phobia, and flying phobia (i.e., Botella, Baños, Villa, Perpiñá, & García-Palacios, 2000; Emmelkamp et al. 2002; García-Palacios, Hoffman, Carlin, Furness, & Botella, 2002; Rothbaum, Hodges, Anderson, Price, & Smith, 2002; Wiederhold, Jang, Gevirtz, Kim, Kim, & Wiederhold, 2002). The findings support that VR exposure is as effective as in vivo exposure and some of the studies offer long-term efficacy (six and twelve month follow-ups). Another line of research in the study of treatment effectiveness is to investigate the mechanisms of change associated to the success of VR exposure. The data regarding this important issue are very scarce. The aim of this work is to contribute to the study of predictors of outcome in the field of VR exposure treatments. VR has some unique features that may be involved in its efficacy and can play a role as predictors of outcome. One important aspect in VR treatments is the degree of presence that the patient feels in the virtual environment. We could hypothesize that the more presence the patients feel the more they will be involved in the treatment and the more effective it will be. Another set of variables could influence treatment response. There are some psychological differences that may be relevant to the VR experience like hypnotizability, dissociation, absorption, imagery, etc. In this work we are interested in two of these variables: Absorption (the tendency to become involved in a perceptual, imaginative, or ideational experience) and dissociation (the tendency to experience disruptions in the integrated functions of consciousness, memory, or perception of the environment). The aim of this work is to study the possible role of presence, absorption, and dissociation in the treatment response to VR exposure therapy. The sample was composed by sixty patients meeting DSM-IV (APA, 2000) criteria for different phobias like claustrophobia, acrophobia, insect phobia, and flying phobia participating in several investigation testing the efficacy of VR exposure.

References

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders DSM-IV-TR (4th ed., text revision).* Washington, DC, APA..

Botella, C., Baños, R. M., Villa, H., Perpiñá, C., & García-Palacios, A. (2000). Virtual reality in the treatment of claustrophobic fear: a controlled multiple baseline design. *Behaviour and Therapy, 31,* 583-595.

Emmelkamp, P. M. G., Krijn, M., Hulsbosch, A. M., Vries, S., Schuemie, M. J. & Van der Mast, C.A.P.G., (2002). Virtual Reality Treatment versus exposure in vivo: A Comparative Evaluation in Acrophobia. *Behaviour Research & Therapy*, 40(5), 509-516.

García-Palacios, A., Hoffman, H., Carlin, A., Furness, T. A. & Botella, C. (2002). Virtual reality in the treatment of spider phobia: A controlled study. *Behaviour Research and Therapy, 40,* 983-993.

Rothbaum, B. O., Hodges, L., Anderson, P. L., Price, L. & Smith, S. (2002). Twelve-month follow-up of virtual reality and standard exposure therapies for the fear of flying. *Journal of consulting and Clinical Psychology*, 70 (2), 428-432.

Wiederhold, B. K.; Jang, D. P.; Gevirtz, R. G.; Kim, S. I.; Kim, I. Y. & Wiederhold, D. (2002). The treatment of fear of flying: A controlled study of imaginal and virtual reality graded exposure therapy. *IEEE Transactions on Information Technology in Biomedicine*, 6 (3), 218-223.

Contact:
Garcia-Palacios, A. Ph.D.
Universitat Jaume I Castellon. (Spain).
Phone: +34 964729725
Fax: +34 964729267
Email: azucena@psb.uji.es

Presenter: Azucena Garcia-Palacios PhD

VIRTUAL REALITY DISTRACTION VS. POST-HYPNOTIC ANALGESIC EFFECTS ON THERMAL PAIN STIMULATION

Garcia-Palacios, A. Ph.D.

Universitat Jaume I Castellon. (Spain).

Patients frequently report severe to excruciating pain during medical procedures. The medical literature shows post-hypnotic suggestions (PHS) can reduce such procedural pain, and recent preliminary clinical studies suggest that virtual reality (VR) distraction may serve as an even more powerful non-pharmacologic adjunct. The present study is the first to examine the individual and combined effects of post-hypnotic suggestions (PHS) and VR. In the present experimental pain study, 104 healthy volunteers participated in a double-blind between-groups design with four groups: (No PHS, No VR), (No PHS, Yes VR), (No VR, Yes PHS), and (Yes PHS, Yes VR). Each subject provided subjective 0-10 ratings of cognitive, sensory, and affective components of pain. Afterwards subjects received a Stanford Hypnotizability test to measure their receptivity to hypnotic suggestions. Immersive VR distraction had robust effects on pain intensity, pain unpleasantness, and time spent thinking about pain regardless of hypnotizability. In contrast, overall post-hypnotic suggestions had relatively weak effects on pain intensity and unpleasantness but had robust analgesic effects for participants with higher hypnotizability scores. For highly hypnotizable subjects there was a pattern suggesting the possibility that VR + PHS combined may reduce pain more than either technique alone. Implications for maximizing pain relief are discussed.

Contact:
Garcia-Palacios, A. Ph.D.
Universitat Jaume I Castellon. (Spain).
Phone: +34 964729725
Fax: +34 964729267
Email: azucena@psb.uji.es

Presenter: Ken Graap MEd

VIRTUAL REALITY AND ADDICTION RESEARCH: UPDATES, STATUS, AND LESSONS LEARNED

Patrick Bordnick, MSW, MPH, PhD[1], Ken Graap, M.Ed.[2], Hilary L. Copp, MSW, Div.[1]

[1] University of Georgia - Gwinnett University
[2] Center Virtually Better, Inc. & Emory University, Department of Psychology

Research Status: Preliminary clinical trials

Background

Since 2001, researchers have developed and tested virtual reality (VR) software and environments across a variety of addictive drugs. Research in addictions has primarily focused on testing the feasibility of VR environments to elicit cued-reactivity (i.e., drug craving and physiological responses). Cue-reactivity involves exposing substance addicted persons to VR drug cues and VR neutral cues while assessing subjective craving and physiological reactivity. Cue reactivity is based on the theory of classical conditioning where drug use is repeatedly paired with environmental stimuli and these stimuli can trigger craving and reactivity. Environmental stimuli are often referred to as cues and may consist of objects (i.e., cigarettes, drug paraphernalia), places (e.g., crack house, bar), people, and scents (i.e., smell of cigarettes or beer). Several controlled experimental trials clearly demonstrate that VR drug environments can elicit craving and physiological responses compared to neutral VR environments in nicotine dependent persons[1,2] and cocaine dependent person.[3] Currently VR environments have been developed for nicotine, cocaine, and alcohol. The marijuana VR environment is being constructed. This presentation will focus on current results and the status of VR environments as well as future directions in the addiction field.

Methods

All studies reviewed and presented are controlled experimental trials with substance dependent samples using strict inclusion and exclusion criteria. Across trials, participants are exposed to both VR neutral stimuli and VR drug related stimuli using a VFX-3D HMD (Interactive Imaging, Rochester, NY) connected to a 2Ghz P-IV PC. VR drug cues consisted of both inanimate (i.e., drug paraphernalia) and animate cues (i.e., social settings where participants are offered their drug of choice) and VR neutral cues (i.e., non-drug related objects or scenes). In addition to the visual cues, recent advances in our lab have led to the addition of olfactory cues into the VR environments. Current data on olfaction in VR cue reactivity will be presented.

Results

Data presented will focus on the comparison of drug craving and autonomic physiological

reactivity between VR drug cues and VR neutral cues. A summary of current data from nicotine, alcohol, and cocaine cue reactivity trials will be presented.

Conclusions

This presentation will provide an overview of VR applications in addiction research and treatment. Past, current and future directions will be discussed along with lessons learned to date.

Novelty/Discussion

This presentation will provide the first overview of VR cue reactivity research to date, including data on controlled alcohol, cocaine, and nicotine trials. The first application of a novel olfactory stimuli presentation system in VR drug research will also be highlighted. Future research and treatment applications will be discussed.

References

1. Bauman, S. B. (2004). Smoking cues in a virtual world provoke craving in cigarette smokers as demonstrated by neurobehavioral and fmri data. Paper presented at the CyberTherapy, San Diego, CA.
2. Bordnick, P. S., Graap, K. M., Copp, H., Brooks, J., Ferrer, M., & Logue, B. (2004). Utilization of virtual reality to standardize nicotine craving research: A pilot study. Addictive Behaviors, 29(9), 1889-1894.
3. Graap, K. M. (2004). Cue reactivity in a virtual crack house. Paper presented at the Association for the Advancement of Behavior Therapy, New Orleans, LA.

Contact:
Patrick S. Bordnick, MSW, MPH, Ph.D.
Virtual Reality Clinical Research Center
University of Georgia -
Gwinnett University Center
1000 University Lane, Suite 3020
Lawrenceville, Georgia 30043 USA
bordnick@uga.edu
678-407-5204

Presenter: Ken Graap MEd

THE ADDITION OF SCENT TO IMMERSIVE VR ENVIRONMENTS IN ADDICTION AND SPEECH PATHOLOGY RESEARCH

Ken Graap, M.Ed.[1,2], Patrick Bordnick[3], Jeremy Brooks[1], Mirtha Ferrer[1], Shelley Brundage[4]

[1] Virtually Better, Inc.
[2] Emory University, Department of Psychology
[3] University of Georgia, Department of Social Work
[4] George Washington University, Department of Speech Pathology

Research Status: Preliminary clinical trials

Background

Scent is one of the most salient senses for emotional response. The olfactory bulbs project into nerve tracts that synapse into the amygdala. The amygdala is connected bidirectionally to the hippocampus, the center of many memory functions. These connections suggest that specific smells may be associated with accessing emotionally laden memories. Herz & Schooler[1] and Herz,[2] have investigated the associations of scent and memory providing an empirical basis for scent research in virtual reality (VR). In respondent conditioning, scents can serve as powerful cues that trigger physiological and subjective responses to past conditioned events. Building upon these studies, we are exploring the use of scent in virtual reality (VR). The addition of scent will extend our previous work in phobias[3] and enhance our research in addictions[4] and speech pathology.[5] This presentation outlines the process of adding scents to several immersive environments being tested in controlled research trials.

Method & Tools

Scent is being utilized in two different and related areas. First, it is being applied to facilitate immersion in VR environments as an ambient stimulus in a job interview designed for use with persons who stutter. Second, scent is being applied directly as a primary stimulus to facilitate craving responses in controlled trials with substance abusing and dependent participants. Examples of such implementations using the EnviroScent machine in conjunction with Virtually Better VR environments will be presented.

Results

Initial data including immersion ratings, and subjected units of discomfort (SUDs) or craving ratings from the trials will be discussed. Qualitative experiences of participants in trials will be discussed.

Novelty

To our knowledge this will be the first time that our Enviroscent Machine will have been used with immersive VR in a clinical setting.

References

1. Herz, R.S., & Schooler, J.W. (2002). A naturalistic study of autobiographical memories evoked to olfactory versus visual cues. American Journal of Psychology, 115, 21-32.
2. Herz, R.S., (2004). A comparison of autobiographical memories triggered by olfactory, visual and auditory stimuli. Chemical Senses, 29, 217-224.
3. Glantz, K., Rizzo, A & Graap, K (2003). Virtual Reality for Psychotherapy: Current Reality and Future Possibilities. Psychotherapy, 40, 55-67.
4. Bordnick P., Graap, K., Copp, H., Brooks, J., Ferrer, M. Logue, B. (2004). Utilizing virtual reality to standardize nicotine craving research: A pilot study. Journal of Addictive Behavior, 29, 1889-1994.
5. Brundage, S. & Graap, K. (2004). Virtual Reality: An exciting new tool to enhance stuttering treatment Perspective on Fluency Disorders, 14, 4-9.

Contact:
Ken Graap, M.Ed.
Virtually Better
2450 Lawrenceville Hwy
Decatur, GA 30033
Phone: 404-634-3400
Fax: 404-634-3482
Email: graap@virtuallybetter.com

Presenter: Simon J. Graham PhD

AN FMRI STUDY EXAMINING SPATIAL NAVIGATION THROUGH A VIRTUAL ENVIRONMENT: PARTIAL LEAST SQUARES ANALYSIS

Richard Mraz, P.Eng.[1], Nancy J. Lobaugh, Ph.D.[1,2], Genevieve Quintin, M.A.[3], Konstantine K. Kakzanis, Ph.D., C.Psych.[3], Simon J. Graham, Ph.D., P.Eng.[1,4]

[1] Imaging Research, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario
[2] Department of Medicine, University of Toronto, Ontario, Canada
[3]Division of Life Sciences, University of Toronto, Ontario, Canada
[4] Department of Medical Biophysics, University of Toronto, Ontario, Canada

Reserach Status: Completed

Several functional neuroimaging studies have studied different specific aspects of human navigation.[1,2,3] To further elucidate regions involved during performance of spatial navigation and to determine how task performance influences the identified brain regions, this study utilized a novel virtual reality (VR) navigation task during functional magnetic resonance imaging (fMRI). The task enabled both learning and recall of routes to be assessed. The multivariate Partial Least Squares analysis (PLS)[4] was used to identify time-varying distributed activity patterns in the fMRI data.

Methods/Tools

The experiment involved navigation through a virtual city using an fMRI-compatible virtual reality platform.[5] The task consisted of a set of 3 learning trials for Path A followed by 1 learning trial for Path B. Each learning trial consisted of two components; passive viewing of the path by video playback, and active navigation using an fMRI-compatible joystick. In subsequent short (5 min) and long (20 min) delay recall trials, Path A was navigated from memory. Twelve, healthy, right-handed subjects participated. Functional MRI experiments were performed at 1.5T (Signa, GE Healthcare). Behavioural metrics included time to completion and distance travelled. For the primary analysis, learning trials were contrasted with recall trials (task-PLS) following motion correction and temporal detrending. Further analysis included a behavioural-PLS in which time to completion was used to determine significant brain-behaviour correlations.

Results

One significant ($p<0.01$) latent variable characterized differences in brain activity between learning trials and recall trials. Design scores denoted significant differing neuronal involvement between conditions. Activation maps indicated that bilateral frontal regions

and right hippocampus were more involved during learning, while parietal and temporal regions, such as the left parahippocampal gyrus, bilateral precuneus and cingulate cortex, were more active during recall. A second task-PLS analysis focused on the 4 learning trials, identifying a pattern related to the first learning trial for each path. Areas involved in initial learning included right precuneus and the cerebellum. Subsequent trials recruited regions surrounding the lateral sulcus bilaterally as well as the middle and medial frontal gyri. The behaviour-PLS confirmed many of these findings among similar brain regions, identifying patterns that were related to general task performance, to initial learning, and that specifically distinguished learning from recall.

Conclusion

Findings of posterior activations during recall are consistent with the notion that temporal regions are involved in spatial information retrieval, whereas initial encoding of a complex route demands increased precuneus involvement. The predominant activation of frontal and temporal regions in subsequent learning trials can probably be associated with encoding, maintenance, and recall of visual cues, which are critical for successful navigation.

Novelty

Combining VR-fMRI with PLS proved to be a highly sensitive technique for examining regions engaged during spatial navigation.

References

[1] EA Maguire, et al. Journal of Cognitive Neuroscience, 10:61-76 (1998).

[2] RPC Kessels, et al. Neuropsychology Review, 10:101-113 (2000).

[3] E Mellet, et al. Neuroimage, 12:588-600 (2000).

[4] AR McIntosh, NJ Lobaugh. Neuroimage, 23:S250-S263 (2004).

[5] R Mraz, et al. Cyberpsychology & Behavior, 6:359-368 (2003).

Contact:
Simon J. Graham, Ph.D., P.Eng.
Sunnybrook and Women's College Health Sciences Centre – S650
Toronto, ON
Canada
Phone: 416-480-4104
Fax: 416-480-5714
Email: simon.graham@sw.ca

Presenter: Kay Howell MBA

IMMUNE ATTACK: BUILDING BIOLOGICALLY BASED IMMUNE SYSTEM SIMULATIONS FOR EDUCATION AND TRAINING

Kay Howell

Federation of American Scientists

Background

A growing literature suggests that simulation, visualization, and gaming can play an important role in deepening understanding of difficult concepts in mathematics, engineering, and science. Learning sciences research suggests that learning by doing with understanding produces better transfer than mere doing alone.[1,2] Challenge-based simulations can provide students opportunities to receive feedback and revise their thinking, a critical part of the learning process.[3,4] *Immune Attack* is a simulation game to teach biological concepts related to immunology and wound infection, allowing the student to explore the internal compartments and cells of the human body and visualize immunological processes.

Method/Tools

Immune Attack will combine 3D visualizations of biological structure and function with advanced educational technologies to provide an introduction to basic concepts in immunology for high school students. It is intended to be as fun and compelling as the computer games currently played by many adolescents and young adults. Students are motivated with a series of progressively more difficult challenges in a gaming environment in which success depends on increasingly sophisticated grasp of concepts in immunology. The learning experience will be individualized by use of context-sensitive help and dialogues and continuous assessment tech-

niques to determine when the learner is ready to move to a new level.

The biological models are being developed working closely with prominent immunology researchers and educators. Experienced video game developers are developing the game and assisting in integrating the learning tools. The learning objectives and instructional strategies are being developed in consultation with biology teachers, at both the high school and college freshmen levels, and with learning research scientists.

Evaluation

The game will be used to supplement imunology taught as a part of biology courses given to high school students and will be valuated in high school biology classes. The project will be evaluated based on the following criteria: 1) Has the project developed biologically correct, visually compelling simulations of the immune system that can be easily navigated by people without specialized technical proficiency? 2) Do the simulations allow revisions and augmentations and encourage use of simulation components in the work of others? 3) Can the simulations be used in conjunction with a variety of assessment, feedback, and augmentation tools? 4) Does use of the game increase students' motivation to learn the classroom material?

Novelty/Discussion

Computer games hold special interest to a generation who has grown up with them, and as such, they show promise as educational tools. Whether this is due to the inherent challenge built into game play, the richness of graphics presented to the user, the opportunity to interact with other users (in web-based games), the story or context in which the game is couched, or some other feature is an important part of this research project. Exploiting the inherent motivational aspects of games and simulations for education and training must be based on a sound understanding of which features of these systems are important for learning and why.

References

1. Barron, B.J., D.L. Schwartz, N.J.; Vye, A. Moore, A. Petrosino, I. Zech, J.D. Bransford, and the Cognitive and Technology Group at Vanderbilt. Doing with Understanding: Lessons from research on problem and project-based learning. Journal of Learning Sciences 7 (3 and 4): 271-312.
2. John D. Bransford, Sean Brophy, and Susan Williams. "When computer technologies meet the learning sciences: Issues and opportunities" in Journal of Applied Developmental Psychology, 21 (1) pp. 59-84.
3. Black, P., and William D. 1998. Assessment and classroom learning. In Assessment and Education. Special issue of Assessment in Education: Principles, policy and practice 5(1):7-75. Carfax Pub. Co.
4. Vye, N.J. , D.L. Schwartz, J.D. Bransford, B.J. Barron, L. Zech, and Cognition Technology Group at Vanderbilt, 1998. SMART environments that support monitoring, reflection, and revision. In Metacognition in Educational Theory and Practice, D. Hacker, J. Dunlosku, and A. Graesser, eds. Mahwah, NJ: Erbaum.

Contact:
Kay Howell
Federation of American Scientists
1717 K. St., NW, Suite 209
Washington, DC 20036
Ph: 202.454.4685
Fax: 202.6751010
Email: khowell@fas.org

Presenter: Eva Hudlicka PhD

A COMPUTATIONAL MODEL OF EMOTION AND PERSONALITY: APPLICATIONS TO PSYCHOTHERAPY RESEARCH AND PRACTICE

Eva Hudlicka, Ph.D.

Psychometrix Associates, Inc.

Research Status: MAMID cognitive-affective architecture is implemented; Applications to psychotherapy research are planned.

Background

VR applications in psychotherapy are gaining prominence in the research community and acceptance among practitioners. However, a promising technology remains unexplored: computational models of cognition and emotion.

Cognitive models (also termed cognitive- or agent-architectures) aim to emulate cognitive

processing such as attention, perception, and decision-making, and are used by cognitive scientists to advance understanding of the mechanisms and structures mediating cognition. These models are also used in applied settings to improve training and human-system design. Recently, architectures have been developed that explicitly represent emotions: both emotion appraisal processes, and effects of emotions on cognition.

In this paper I first describe a cognitive-affective architecture capable of modeling the dynamic generation of emotions (affect appraisal), and some effects of emotions on cognition. I then describe applications of this architecture to psychotherapy research and practice.

Method / Tools

The MAMID cognitive-affective architecture dynamically generates four emotions (anxiety, anger, joy, sadness) from a combination of external and internal stimuli (e.g., incoming sensory cues, goals, expectations). The architecture then models the effects of these emotions, as well as four traits (extraversion, neuroticism, conscientiousness, aggressiveness), on the cognitive processes and structures mediating decision-making and action selection. For example, anxiety-linked threat-bias is modeled by biasing attentional, interpretive and expectation-generation processes to preferentially process threatening stimuli, and derive higher-threat interpretations and expectations. MAMID is able to model a broad range of 'stereotypes' by representing emotion effects in terms of parameters controlling the architecture structures (memory) and processes (e.g., attention, situation assessment).

Results

Feasibility of the model was demonstrated in the context of a simulated peacekeeping scenario, where separate instances of the architecture controlled the behavior of 'stereotypical' unit leaders ('anxious,' 'aggressive,' 'normal'). The same set of external stimuli triggered distinct emotions in the different stereotypes, and their effects on decision-making then caused differences in observable behaviors. The MAMID architecture is domain-independent, to facilitate transitions to other domains, including psychotherapy.

Novelty / Discussion

There is great potential for application of cognitive-affective models in psychotherapy research and practice; both in a "stand-alone" mode, and coupled with synthetic avatars, to produce more realistic virtual characters.

Research MAMID provides a tool for modeling the etiology and treatment of a variety of disorders; e.g., the positive feedback cycle characterizing generalized anxiety disorders and phobias could be modeled by representing the increasing predominance of anxiety-related schemas in the patient's long-term memory, increased sensitivity to anxiety-producing stimuli, and generalization across previously neutral stimuli. Results of cognitive restructuring could be modeled by 'exposing' models to repeated simulated inputs representing therapeutic interventions or changing social contexts, and modeling the gradual emergence of more adaptive memory schemas, interpretations, and behavior. Improved understanding of these processes would provide opportunities for more finely-tuned assessment and treatment.

Clinical Practice MAMID provides a means of controlling the behavior of avatars in therapeutic virtual environments, thereby enhancing their believability. The avatars would represent specific stereotypes (e.g., 'aggressive audience member,' 'shy friend'), allowing the construction of virtual social situations relevant for the patient. The use of affectively-realistic avatars, embedded within simulated situations, would also enhance assessment.

Contact:
Eva Hudlicka
Psychometrix Associates, Inc.
Blacksburg, VA, USA
Phone: (01) 540 552 4803
Email: evahud@earthlink.net

Presenter: Wijnand IJsselsteijn, Ph.D.

TOWARDS A NEUROPSYCHOLOGICAL BASIS OF PRESENCE

Wijnand IJsselsteijn, Ph.D.

Eindhoven University of Technology

In this presentation, we will review recent neuropsychological studies regarding tool

use and body image perception, and highlight their importance for understanding presence.

The experience of presence appears to be a complex perception, formed through an interplay of raw multisensory data, spatial perception, attention, cognition, and motor action, all coupled through a constant dynamic loop of sensorimotor correspondence. Presence research studies the experience of being in a place or being with someone as it is mediated through technology.

The perception of ourselves as part of a space not only depends on a passive perception of spatial layout but also on the ability to actively explore an environment, allowing the perceptual systems to construct a spatial map based on sensorimotor dependencies. By incorporating telepresence technology that supports our bodily perceptual and control movements as part of the ongoing perceptual-motor loop, the correlations between motor actions and multisensory inputs remain intact and a sense of telepresence or 'distal attribution' may occur.

The fact that technology can start working as a transparent extension of our own bodies is critically dependent on the highly plastic nature of our brain, which is continuously able and prone to adapt to altered sensorimotor contingencies. This fact finds its basis in the significant evolutionary benefit of having a negotiable body image to accommodate lifetime development and change, which requires a continuous remapping of bodily boundaries. A radical example is provided by the amazing adaptation processes that occur in the body-image of people with one or more lost or amputated limbs.[1] Although body-image adaptations across the lifespan can afford to take their time, it is the relative speed of these sensorimotor adaptations that enables us to experience man-made technology as, quite literally, part of ourselves - be they a blind person's cane or an advanced telerobotic arm.

In general, the space that surrounds an individual can be meaningfully segmented into near or peripersonal space and far or extrapersonal space. Animal and human brain studies have confirmed this distinction, showing that space is not homogeneously represented in the brain.[2,3] Telepresence technologies can be viewed as attempts to overcome the boundaries of spatial segmentation. Their success in doing so is evidenced by a clinical case, described by Berti and Frassinetti,[4] where a patient, after a right hemisphere stroke, showed a dissociation between near and far spaces in the manifestation of neglect. Using a line bisection task, the neglect was apparent in near space, but not in far space when bisection in the far space was performed with a projection light pen. However, neglect appeared when in the far space bisection was performed with a stick (used by the patient to reach the line) and it was as severe as neglect in the near space. Thus, this study provides evidence that an artificial extension of a person's body (the stick) causes a remapping of far space as near space – essentially telepresence.

References

1. Ramachandran, V.S. & Blakeslee, S. (1998). *Phantoms in the Brain.* New York: Harper Collins.
2. Rizzolatti, G., Fadiga, L., Fogassi, L. & Gallese, V. (1997). The space around us. *Science 277*, 190-191.
3. Previc, F.H.. (1998). The neuropsychology of 3-D space. *Psychological Bulletin 124*, 123-164.
4. Berti, A. & Frassinetti, F. (2000). When far becomes near: Remapping of space by tool use. *Journal of Cognitive Neuroscience 12*, 1215-420.

Contact:
Wijnand IJsselsteijn, Ph.D.
Eindhoven University of Technology
Eindhoven, The Netherlands
Phone: +31 40 2474455
Fax: +31 40 2449875
Email: W.A.IJsselsteijn@tue.nl

Presenter: Hee Jeong Jang

INVESTIGATION OF SOCIAL ANXIETY OF PATIENTS WITH SCHIZOPHRENIA USING VIRTUAL AVATAR

Hee Jeong Jang, BA, [1], Jeonghun Ku, PhD[2], Sung Hyouk Park, MS[1], So Young Kim, BA[1] In Y. Kim, MD, PhD[2], Chan-Hyung Kim, MD, PhD[1], Jae-Jin Kim, MD, PhD[1]

[1] Yonsei University College of Medicine
Severance Mental Health Hospital, Gyunggi-do, Korea
[2] Dept. of Biomedical Engineering, Hanyang University, Seoul, Korea

Backgrounds

Patients with schizophrenia show a tendency to avoid social interaction because they feel great anxiety during their social interactions. Therefore, they have trouble making social relationships. This trouble is largely due to the fact that the patients have emotional withdrawal as well as passive/apathetic social withdrawal. These social deficits of patients has been overcome through social skills training programs, which provide them opportunities to experience previously various social situations by role play method.

Objectives

This study was conducted in order to investigate whether an interaction with virtual avatars can evoke patient's social anxiety and the relationship between patient's symptom severity and social anxiety traits.

Method/Tools

Fifteen patients with schizophrenia and fifteen control people were recruited. A male and a female avatar were generated. 2×2×3 (group, avatar's gender and avatar's emotional expression) was used in this experiment. Each avatar has three emotional expressions, which are happy, neutral, and angry. Subjects performed an introduction task in six conditions (gender × emotional expression) in a random order. The task is composed of "approach," "listening to an avatar's introduction," and "introducing oneself to the avatar." After all six tasks were performed, subjects completed a State-Trait Anxiety Inventory (STAI) questionnaire. In addition, patient's symptom severity was evaluated using the Positive and Negative Syndrome Scale (PANSS).

Results

The social anxiety level to avatar's emotional representation was significantly different in both group ($p<.001$). In control group, the level was lowest when subjects coped with an avatar expressing "happy," while the highest anxiety level was shown when they faced to an avatar expressing "anger." However, in patient groups, the level difference was not significant between "neutral" and "happy" avatars. Patients only showed a significantly high anxiety level when they experience "angry" avatar conditions compared to the other two conditions. In a correlation analysis between patient's anxiety levels and the severity of their symptoms, social anxiety on "happy" and "neutral" avatars was positively correlated with the negative syndrome of PANSS (happy : $r=.539$, $p=.038$, neutral : $r=.533$, $p=.041$). Particularly, the anxiety level by "happy" and "neutral" avatars was positively correlated with two subscales (N1: blunted affect, N4: passive/apathetic social withdrawal) of the negative syndrome of PANSS (N1. happy: $r=.549$, $p=.034$/ neutral: $r=.536$, $p=.039$) (N4. happy: $r=.536$, $p=.039$/ neutral: $r=.658$, $p=.008$).

Conclusion

Through this study, we found that virtual avatar's emotional expressions could cause social anxiety to patients with schizophrenia and that patient's symptom severity was correlated with social anxiety during the time they coped with avatars. These results show that the more severe negative symptoms a patient has, the higher social anxiety they feel. It might be due to their passive, apathetic, and isolated traits. Therefore, they tend to recognize even socially positive emotion as fearful stimuli. This inference could be supported by the relationship between anxiety and subscales of negative symptom of PANSS. In this sense, we could say that a virtual avatar could provide an opportunity for patients to experience emotion induced social situations. In addition, it could be used for training them to cope effectively by experiencing emotions close to reality as well as to find out the clinical characteristics related to patient's symptoms.

Contact:
Hee Jeong Jang
Mind Mapping Laboratory
Institute of Behavioral Science in Medicine
Yonsei University College of Medicine
Email: saccylia@hanmail.net

Presenter: Naomi Josman PhD

VIRTUAL REALITY: INNOVATIVE TECHNOLOGY FOR THE TREATMENT FOR VICTIMS OF TERRORIST BUS BOMBING WITH POST-TRAUMATIC STRESS DISORDER (PTSD)

Naomi Josman[1], Ayelet Reisberg , Eli Somer, Hunter Hoffman, Azucena Garcia-Palacios, Ari Hollander, Russ Shilling, Patrice (Tamar) Weiss

[1] University of Haifa

Research Status: Preliminary clinical trials (case report) currently in progress

Background/Problem

Cognitive Behavioural Therapy (CBT) with exposure involves having patients gradually remember the traumatic event and process the extreme emotions associated with that memory so they can eventually remember the traumatic event in a more healthy way. CBT with exposure is currently the treatment of choice for Post Traumatic Stress Disorder (PTSD). There is strong empirical support for the efficacy of CBT interventions for PTSD for those who seek and complete treatment. Unfortunately, avoidance of remembering the traumatic event is a defining symptom of PTSD, and the majority of people who develop PTSD avoid seeking treatment. Those needing treatment most may be the most likely to avoid or drop out of traditional treatment. CBT with exposure provides patients with opportunities to learn to control their own emotional responses when confronted with stimuli that elicit physiological and emotional activation. In order to develop new, healthier patterns of thinking, feeling, and acting toward the distressing stimuli, CBT requires the practice of new beliefs and actions in the presence of stimuli that elicit the anxiety. CBT and Virtual Reality (VR) provide patients with an ideal context for gradually remembering memories of the traumatic event. VR may help increase emotional engagement and treatment success. VR is proving effective even for difficult patients who have failed to respond to traditional therapy.[1] Surveys suggest that patients with anxiety disorders are much more receptive to VR than to traditional therapy, perhaps because VR has fewer stigmas, is more interesting, and less threatening than traditional therapy.

Method/Tools

The patient we treated met diagnostic criteria for PTSD after directly witnessing a terrorist bus bombing attack in Haifa, Israel, and received a 9–visit treatment protocol that incorporates CBT+VR. Among other things, treatment involves viewing scenes of the terrorist bus bombing attack through a position tracked 3-D VR helmet. The scenes, computer controlled by therapist button pushes, progress in severity, culminating in a bus pulling up to a bus stop in an Israeli town, exploding into smoke and flame with loud sound explosion effects (with vibrotactile augmentation via amplified speakers) with accompanying sounds of screaming and sirens, and a smouldering limb in the street. The subject completes self-report questionnaires and is assessed prior to and following the treatment by two experienced clinicians (one clinician blind to treatment condition).

Conclusion

VR exposure therapy is a promising new medium for treating PTSD from terrorist bus bombing attacks.

Novelty/Discussion

There are currently no controlled studies in the literature on the topic of using VR exposure therapy for treating PTSD. The current project addresses a completely original research topic on a rapidly growing patient population (using VR to help treat PTSD from terrorism). In Israel, there have been dozens of extremely violent deadly terrorist attacks involving civilians causalities and deaths (often including women and children) in the past few years alone. PTSD is a very challenging psychological disorder to treat, yet the social and economic cost of the current trend of leaving so many PTSD victims untreated is unacceptable.

References

1. Difede, J., Hoffman, H. & Jaysingle, N. (2002). Innovative use of virtual reality technology in the treatment of PTSD in the aftermath of September 11. *Psychiatric Services, 53*(9), 1083-1085.

Contact:
Naomi Josman, Ph.D.
Department of Occupational Therapy
University of Haifa
Haifa, Israel
Tel: +972 4 824-0610
Email: naomij@research.haifa.ac.il

Presenter: Hannes Kaufmann PhD

GENERAL TRAINING OF SPATIAL ABILITIES BY GEOMETRY EDUCATION IN AUGMENTED REALITY

Hannes Kaufmann[1], Karin Steinbügl[1], Andreas Dünser[2], Judith Glück[2]

[1] Institute of Software Technology and Interactive Systems, Vienna University of Technology
[2] Institute of Psychology, University of Vienna

Geometry education has proven as one powerful means of improving spatial abilities, an important component of human intelligence. In the first part of this paper we summarize our development of a system that uses collaborative augmented reality as a medium for teaching, and uses 3D dynamic geometry to facilitate mathematics and geometry education. Our immersive collaborative educational application, specifically developed for geometry education, serves as the basis of a comprehensive evaluation study regarding its efficacy in training spatial abilities. The main contribution is the description of evaluation design including the test instruments, learning tasks, and practical experiences with using our system for actual training of high school students. Results of a pre-study with spatial ability tests in high schools are presented. They point to interesting gender-specific differences of strategies when solving spatial ability tests, which have not been reported in literature before.

Contact:
Hannes Kaufmann
Institute of Software Technology and Interactive Systems
Vienna University of Technology
Favoritenstr. 9-11/188-2
A-1040 Vienna, Austria
Email: kaufmann@ims.tuwien.ac.at

Presenter: Steven Kerr MSc

AS INTERACTIVE: DEVELOPMENT AND USE OF VIRTUAL ENVIRONMENTS FOR SOCIAL SKILLS TRAINING

Steven Kerr and Sue Cobb

Human Factors Research Group, University Of Nottingham

Research status: Completed

Virtual Environments (VEs) offer the potential for users to explore social situations and 'try out' different behaviour responses for a variety of simulated social interactions. The AS Interactive project was a three-year programme of study to examine the use of virtual environments for social skills training of young people and adults with autistic spectrum disorders (ASDs) and Asperger's Syndrome (AS). The project research team comprised computer scientists, virtual environment developers, human factors researchers, psychologists, and autism training specialists working with individuals from AS social groups and students and teachers from autism specialist schools.

The first consideration of the project was the feasibility of constructing usable social environments using virtual reality technology. Two types of virtual environments were evaluated; single user virtual environments (SVEs) and collaborative virtual environments (CVEs). In the SVE the user was guided through a social interaction task and invited to make choices about what to do and what to say in situations represented within a virtual café and a virtual bus. In the CVE several users, positioned at different PCs, simultaneously shared the same virtual environment, representing a virtual café or an interview scenario. The intended use of the CVE was that a teacher or training advisor could support the user by taking the role of one of the other characters and providing guidance using virtual social interaction.

Observation studies found that SVEs were much more successful than CVEs as the latter was too complex, technologically, to set up in school and users tended not to engage with other avatars in conversation. SVEs however could be used in one to one tuition, which gauged the suitability of the program for individual students and identifying their level of understanding or in group exploration and reflection (where a teacher led a discussion with a small group of students viewing the VE on a projected screen) which was useful for identifying social cues in the VE and understanding the perspectives of others.

The conclusions drawn from this project were that successful VEs for teaching social skills to people with Asperger's Syndrome (AS),

will need sufficient scaffolding inbuilt to support learning whilst also having the flexibility to adapt for unforeseen problems through teacher intervention. Allowing a teacher to individualise the content of the VEs in some way is important, as it should not be assumed that a student has understood the lesson by appearing to exhibit the appropriate behaviour for the given task. Some behaviour might be individual to that user and only someone who knows the user will understand this. This paper aims to discuss the issues behind the design and development of the SVEs and the features which can be used to facilitate the teaching of social skills to people with AS, who have very individualised needs.

Contact:
Steven Kerr
Virtual Reality Applications Research Team
Human Factors Research Group
University Of Nottingham
Tel: +44 (0) 115 9514070
Fax: +44 (0) 115 8466771
Email: steven.kerr@nottingham.ac.uk

Presenter: Jaehun Kim

DEVELOPMENT OF VR SYSTEM TO ASSESS SOCIAL PROBLEM SOLVING ABILITY FOR PATIENT WITH SCHIZOPHRENIA

Jaehun Kim, M.S.; Kwanguk Kim M.S.; Kiwan Han, B.S.; Jeonghun Ku, Ph.D.; Hee Jeong Jang, B.A.; Sung Hyouk Park, M.D.; So Young Kim, B.A.; Chan Hyung Kim, M.D., Ph.D.; Jae-Jin Kim, M.D., Ph.D.; Jang Han Lee, Ph.D.; In Young Kim, M.D., Ph.D.; and Sun I. Kim, Ph.D.

Department of Biomedical Engineering, Hanyang University

Background/Problem

Patients with schizophrenia usually lack social skills and have an inability to communicate effectively with people, confirm and express their feelings, and understand interpersonal boundaries. They may solve their problems in an unsuitable manner or they may have few solutions. In this study, we developed the Virtual Reality system to measure social problem solving ability according to the state of illness of the patient with schizophrenia.

Method/Tools

We developed a project-based VR system because schizophrenic patients feels very anxious when wearing a Head-mounted display. Narrative-based contents were constructed to induce schizophrenic patients into proper goals to assess social problem solving abilities. Survey for selecting 8 complicate social problems among many daily-happening social problems and setting their difficulty was conducted for 50 normal people. The virtual environment and virtual avatar matched with 8 complicated situations were built by using 3D-MAX and were converted into MAP or MDL format for rendering in A6 engine. The behavioural database which consists of 15 avatars, 40 apparels, 70 actions and 6 facial expressions was constructed to make a flexible and dynamic avatar. Also eye-blinking and lip-synching was roughly implemented to make the virtual avatar more realistic and live-like. The VR system was designed to give patients the information that is needed in problem solving because we want to measure the pure social problem solving ability except cognitive aspects such as memory. It was implemented by making an information window in which patients know what time it is, how much money I have, today's schedule, and what I should do. After VR experience in each content, Q&A panels about the complicated situation appeared and patients could select their own solution about given social problems by using an 8-button joystick.

Results/ Conclusion

In this study, we designed a VR system to assess schizophrenic's social problem solving ability except the cognitive ability of schizophrenia. Reaction time responding to the Q&A panel and problem solution in given social VR situation is extracted from the proposed VR system to assess social problem abilities. After having experiences in session, schizophrenia answers following questions: computer experience scale, immersive tendencies questionnaire, virtual reality questionnaire, social problem solving index, positive and negative syndrome scale, KWIS. Now we are gathering data from associated hospital and have a plan to validate usability and effectiveness of proposed VR contents by showing that VR parameters are closely correlated with the traditional assessment

tools e.g. SPSI.

Novelty/Discussion

In this study we develop a VR system for patients with schizophrenia to perceive more realistic and dynamic situations, which could be difficult when constructed from other media such as text, pictures, or video. However additional research of the usability and validation of the proposed VR system is needed and is being conducted in our lab.

Contact:
Jaehun Kim
Department of Biomedical Engineering
Hanyang University
Email: jaehunkim@bme.hanyang.ac.kr

Presenter: Kwanguk Kim MS

INVESTIGATION OF SOCIAL CUE PERCEPTION IN SCHIZOPHRENIA USING VIRTUAL REALITY

Kwanguk Kim, M.S.[1], Jaehun Kim, M.S.[1], Daeun Park, B.S.[1], Jeonghun Ku, Ph.D.[1]; Hee Jeong Jang, B.A.[2]; Sung Hyouk Park, M.D.[2]; So Young Kim, B.A.[2]; Chan Hyung Kim, M.D.' Ph.D[2]; Jae-Jin Kim, M.D., Ph.D[2]; Jang Han Lee, Ph.D.[1]; In Young Kim, M.D., Ph.D.[1], and Sun I. Kim, Ph.D[1]

[1] Department of Biomedical Engineering, Hanyang University
[2] Institute of Behavioral Science in Medicine, Yonsei University Severance Mental Health Hospital

Background/Problem

Impairment in social skills is one of the few criteria that all individuals diagnosed with schizophrenia must meet. Successful social skill requires the coordination of many skills, including social perception that involve the decoding and interpretation of social cues in others. Previous research on the social perception in schizophrenia has focused on the interpretation of emotion from facial expressions. Recently, there have been reports on the potential of virtual reality (VR) in social skills training. In this study, we developed VR for social perception assessment including the interpretation of non-facial expressions. And we hypothesized that schizophrenic subjects would perform significantly more poorly than normal subjects on the VR test.

Method/Tools

For the effective social perception test, VR may be needed to compose various situations and contents. So, we used VR Behaviour & Facial Data Base architecture (VRBFDB) for easy and fast VR composition. This architecture is composed of predefined 93 behaviours and 7 facial expressions data base. In this data base, we selected behaviours and facial expressions according to contents. And, VR of 35 contents is developed. The contents can be divided into two sub-contents "Attention to and interpretation of relevant cue test" and "Emotion Recognition test." "Attention to and interpretation of relevant cue test" is composed of non-verbal social situation, recognition, and verbal social situation recognition, and "Emotion Recognition test" is composed of happy, sad, angry, and surprise facial expression recognition. The 21 contents are selected from 35 contents based on 70% selection of normal subjects. The subjects consisted of 17 patients (12 males and 5 females) and 19 controls (12 males and 7 females). This study measured VR data, questionnaire data, and symptom data. VR data included participant's response results, reaction time, presence, and experience of computer. Questionnaire data included age, education, gender, intelligence (K-WAIS) and so on. Symptom data is measured by PANSS (Positive and Negative Syndrome Scales).

Results/Conclusion

According to analyzed results, schizophrenic subjects perform significantly more poorly than normal subjects on the VR test (difference 0.86). In detail, the difference is 0.90 in "Attention to and interpretation of relevant cue test" and 0.82 in "Emotion recognition test." One result shows that emotion recognition test corresponds with established research on schizophrenia on emotional facial recognition. And, the other result shows that relevant cue test is showing that schizophrenia also has a difficulty to recognize social cues.

Novelty/Discussion

In this study, we developed and used Virtual Reality Behavior & Facial Data Base (VRBFDB) for saving developing times and costs. And we apply VR to finding the differ-

ence between schizophrenic subjects and normal subjects in social cue perception.

Contact:
Kwanguk Kim M.S.
Department of Biomedical Engineering
Hanyang University
17 HAENG-DANG DONG SEONG-DONG GU
Seoul 133-605, Korea
Phone: +82-2-2290-0693
Fax: +82-2-2296-5943
Email: kwang6@bme.hanyang.ac.kr

Presenter: So Young Kim

THE RELATIONSHIP BETWEEN INTERPERSONAL DISTANCE AND SYMPTOMS OF SCHIZOPHRENIA ACCORDING TO DIFFERENT EMOTIONAL CATEGORIES USING VIRTUAL REALITY

Sung Hyouk Park[1,2], M.D., So Young Kim[2], B.A.
Jeonghun Ku[3], Ph.D., Hee Jeong Jang[2], B.A., Won Yong Hahn[3], M.S., In Young Kim[3], M.D., Ph.D., Sun I. Kim[3], Ph.D., Chan-Hyung Kim[1,2], M.D., Ph.D., Jae-Jin Kim[1,2], M.D., Ph.D.

[1]Department of Psychiatry, Yonsei University College of Medicine
[2]Mind mapping laboratory, Institute of behavioral science in medicine,
Yonsei University College of Medicine
[3]Department of Biomedical Engineering, Hanyang University, Seoul, Korea

Schizophrenia is a disease characterized by social impairment. Adequate interpersonal distance is important for good interpersonal relationship and for the social rehabilitation of schizophrenia. There have been few researches about interpersonal distance of schizophrenia. We tried to improve the method of presenting stimuli through virtual reality. We constructed virtual environment and virtual avatar with gradual facial expressions. Fifteen schizophrenic patients and control subjects participated in this experiment. This experiment is consisted of 6 blocks. In each block, subjects were asked to approach the avatar with gradual facial expressions representing one emotional category, to the most comfortable place and introduce themselves. We measured the distance subjects took from the avatars. We explored the characteristics of interpersonal distances of schizophrenia and the relationship among the distances, symptoms of schizophrenia and emotional categories (happy, neutral or angry). There were major effects of group and emotion on distances. There were an inverse correlation between the distances from avatars with angry emotion and negative symptoms. These results suggest that negative symptoms of schizophrenic patients may have an association with deficit of social skills and that negative symptoms of schizophrenia may have effects on processing of emotions, especially of negative valence.

Contact:
Sung Hyouk Park
Email: inuone@hanmail.net

Presenter: Evelyn Klinger

VIRTUAL REALITY THERAPY FOR SOCIAL PHOBIA: ITS EFFICACY THROUGH A CONTROL STUDY

Evelyne Klinger, ENG., PhD.candidate[1, 6], Stéphane Bouchard [2], Ph.D., Patrick Légeron, M.D.[3], Stéphane Roy, Psy.[3], Françoise Lauer, Psy.[4], Isabelle Chemin, M.A.[1], and Pierre Nugues, Ph.D.[5]

[1] ENSICAEN-GREYC, Caen, France
[2] University of Quebec in Outaouais, Gatineau, Quebec, Canada
[3] CBT Unit, Sainte-Anne Hospital, Paris, France
[4] Stimulus, Paris, France
[5] LTH Department of Computer Science, Lund University, Sweden
[6] GET/ENST-Paris, CNRS/LTCI, Paris, France

Research status: Completed control study

The efficiency of virtual exposure for phobic disorders has been confirmed by several studies, especially in the case of the fear of public speaking (FOPS). However, FOPS is a less severe subtype of social phobia and does not reflect entirely the diversity of social situations that could potentially induce anxiety. In an earlier study, we reported a virtual reality (VR)-based clinical protocol designed to assess the efficacy of a Virtual Reality Therapy (VRT) on a larger set of social phobias compared to a validated psychological treatment (group-CBT= Cognitive Behavior Therapy). The virtual environments (VEs) used in the treatment recreate four situations dealing with social anxiety: performance, intimacy, assertiveness, and scrutiny. With the help of the therapist, the patient learns adapted cognitions and behaviors in order to reduce anxiety in the corresponding real situations.

The study is based on a pre-post design where the control condition is a gold-standard treatment. Thirty-six participants, diagnosed with social phobia and meeting the inclusion and exclusion criteria, were matched on either VRT or group-CBT. Both treatments lasted twelve weekly sessions and were delivered according to a treatment manual in the presence of a CB-therapist. In VRT condition, sessions were individual and lasted about 45 minutes, with less then 20 minutes of exposure to the four VEs either for assessment or therapy, while in group-CBT condition two hours sessions were delivered with about eight people, a format which allows creating multiple social situations. In both cases, further exercises were prescribed *in vivo* application of the principles developed during the sessions. The participants were submitted to "pre-post" assessment of the full spectrum of social phobia, from key symptoms to global functioning.

Using repeated measures ANOVAs (2 Conditions x 2 Temps), three families of hypotheses were tested: social phobia (as measured with LSAS score and subscores), social functioning (assertiveness - Rathus and SCIA), and general functioning. Given these hypotheses and the use of a gold-standard control condition, the results include the effect-sizes of the Condition by Time interactions and the estimates these differences' importance. They indicate that both treatments were highly effective to reduce social anxiety and social avoidance and to improve social as well as global functioning, with no significant differences between the two treatments except assertiveness.

Our results clearly show the efficacy of virtual reality in the treatment of social phobia. They also demonstrate that people can react emotionally to virtual humans and their behaviors, even if they are unrealistic representations of humans. A promising explanation can be found in the interplay between believability of a virtual reality and emotions felt by the user immersed in the virtual environment.

These statistical analyses represent a new step in the use of our collected data, and in the comprehension of emotional contexts. Interesting features of our research are the selection of a sample composed of young adults showing clinically significant and lasting social phobia, the use of VEs that tackle diverse social situations, and the assessment of the full spectrum of social phobia.

References

North, M., North, S., and Coble, J.R. (1998). Virtual Reality Therapy : An effective Treatment for the Fear of Public Speaking. *International Journal of Virtual Reality.* 3 (2):2-6.

Roy, S., Klinger, E., Légeron, P., Lauer, F., Chemin, I., and Nugues, P. (2003). Definition of a VR-based protocol to treat social phobia. *Cyberpsychology & Behavior.* 6 (4):411-420.

Contact:
Evelyne Klinger
43, rue Appert
44100 Nantes France
Tel: +33 2 40 69 59 21 (home)
Fax: +33 2 40 69 59 21 (home)
Email: klinger@enst.fr

Presenter: Manfred Krapp MD PhD

THE COMPUTER AS A HELPMATE FOR IMAGINATION

Dr. med. Manfred Krapp

C.G. Jung-Institute Zuerich

This paper deals with virtual reality (VR) and Cyberspace from a psychoanalytical point of view, especially regarding the analytical psychology of C.G. Jung. Electronic media have basically changed the relationship between the Ego and the unconscious. The discourse of electronic media is right-hemispherical and *imaginal* and corresponds to the primary process of the unconscious. Flusser emphasises a new faculty of imagination, "computer images simulate brain processes. The images that form there are almost directly projected from the brain to the outside," they are "dreams made exact." This contrasts to the secondary process of the Ego which is characteristic of the left hemisphere of the brain and of alphabetic writing and print with its linear-perspectival discourse (Mc Luhan). The electronic media has relativised time and space in the same way as the border between individuals and between ego and unconscious which become more permeable and flexible.

Based on this point of view I will reflect on the possibilities and limits of VR and Cyber-

space. The space of inner images can be represented very well by the means of hypertext with its manifold refer ability and simultaneity. This is exemplified by a borderline-patient's initial imagery which are analysed by the means of the computer-interpretation-support system ATLAS/ti. It is based on the proceedings of Grounded Theory and was specifically developed for the requirements of qualitative, hermeneutic research. It is based on semantic network representations and realizes in this way the hypertext structure.

Referring to this case the capacity of cybertherapy is discussed, how it could function like art therapy in a broader sense fostering the emergence of inner images, and symbols with their creative potential and self-healing forces. In analytical psychology and art therapy active participation on creating individual metaphors, images and symbols is necessary in order to strengthen the ego and to restore the capacity of symbolisation and imagination. Cybertherapy could be a therapeutic tool for concretizing and structuring the primary process material as it emerges in analytical treatment offering a symbolic and archetypal imagery for the patient.

Contact:
Manfred Krapp, MD, PhD
C.G. Jung-Institute Zuerich
Berlin, 10711
Germany
Phone: ++49308911503
Fax: ++493089096830
Email: manfred.krapp@t-online.de

Presenter: Jeonghun Ku PhD

RELATIONSHIP BETWEEN SOCIAL RESPONSE TO VIRTUAL AVATAR AND SYMPTOM SEVERITY OF PATIENTS WITH SCHIZOPHRENIA

Jeonghun Ku[1] Ph.D., Won Yong Hahn[1], M.S., Hee Jeong Jang[2], B. A., Sung Hyouk Park[2], M.D., So Young Kim[2], B.A., Kwang Uk Kim[1], M.S., Jae Hun Kim[1], M.S., Jang Han Lee[1], Ph.D., Chan-Hyung Kim[2], M.D., Ph.D., Jae Jin Kim[2], M.D., Ph.D., In Y. Kim[1], M.D., Ph.D., and Sun I. Kim[1], Ph.D.

[1]Dept. of Biomedical Engineering, Hanyang University, Seoul, Korea
[2]Department of Psychiatry, College of Medicine, Yonsei University, Severance Mental Health Hospital, Gyunggi-do, Korea

Background

A virtual avatar has been used for various applications that require communication among persons, or to train or educate people by demonstrating human-like behavior. Recently, much research has shown an enhancement of virtual avatar technology, with the avatar perceived as a real person. As a result, the technology could begin to be used for observing human behavior to a virtual avatar.

Objectives

This paper concerns whether a virtual avatar could be perceived as a real human by patients with a mental illness, particularly schizophrenic patients, as well as whether a virtual avatar could acquire patients' behavioral characteristics during a short conversation.

Method/Tools

For this, we designed a virtual avatar that was standing in a virtual room, with eleven schizophrenic patients assigned the task of approaching the virtual avatar, initiating a conversation, and providing answers to the avatar's questions. To measure behavioral parameters in the virtual environment, we acquired the interpersonal distance and the verbal response time. In addition, we rated patients on the Positive and Negative Syndrome Scale (PANSS) in order to investigate a relationship between patients' symptomatic characteristic and behavioral parameters.

Results

Results of this study revealed that the interpersonal distance was negatively correlated with the negative syndrome scale, which is a subscale of PANSS ($r=-0.687$, $p=0.02$). By contrast, the verbal response time was not correlated with any other subscale of PANSS. However, after analyzing this variable with sub-items of the negative syndrome of PANSS, two positive correlations were found: one with blunted affect ($r=.638$, $p=.035$) and the other with poor rapport ($r=.615$, $p=.044$).

Discussion

The negative correlation between the distance and negative symptom severity observed in this study could represent that they keep closer distance during interacting with an avatar due to patient's symptom severity. Therefore, it also could be said that the severer negative symptom patients have, the harder they recognize or interact with the other expressing emotion in a social interaction. This result is consistent with previous studies that investigated the relationship between schizophrenic patients' interpersonal distance and their symptoms. And. the positive correlation between the verbal response time acquired and subscales in PANSS in this study could be explained by the definition of these subscales. The blunted affect score represents the amount of emotional change, which is characterized as the reduction of facial expression, emotional modulation, and gesture during communication. By contrast, the poor rapport score represents the amount of intimacy to an interviewer or the level of deficit in forming a relationship, which is characterized as distancing a human relationship and the reduction of verbal and nonverbal communication. Therefore, this positive correlation means that the less a patient's emotional response, intimacy, and relationship making with a virtual avatar, the slower they answer the avatar's question. Inferring from these results, we conclude that the virtual avatar could be perceived as a real human by schizophrenic patients, the avatar could facilitate the schizophrenic patients' behavioral characteristics, and the avatar could be used as a tool for assessing the behavioral characteristics of patients with schizophrenia.

Contact:
Jeonghun Ku
133-605 Dept. of Biomedical Engineering
Hanyang University,
Sung Dong P.O. Box 55
Seoul, Korea,
Tel : +82-2-2290-0693
Fax : +82-2-2296-5943
Email: kujh@bme.hanyang.ac.kr

Presenter: Jeonghun Ku PhD

GENERATION AND VALIDATION OF DYNAMIC FACIAL EXPRESSION OF AVATAR

Jeonghun Ku Ph.D., Won Yong Hahn, M.S., Hee Jeong Jang, B. A., Sung Hyouk Park, M.D., So Young Kim, B.A., Kwang Uk Kim, M.S., Jae Hun Kim, M.S., Jang Han Lee, Ph.D., Chan-Hyung Kim, M.D., Ph.D., Jae Jin Kim, M.D., Ph.D., In Y. Kim, M.D., Ph.D. and Sun I. Kim, Ph.D.

Dept. of Biomedical Engineering, Hanyang University, Seoul, Korea

Background

Facial expression research has been issued on areas such as social psychology, psychiatry, and so on. Particularly, patients with mental illness showed deficits in reading and recognizing facial expression, so that they suffer from their social life due to the deficit. These studies mostly focused on facial recognition ability and were conducted with still images of people. However, the still images as stimuli have limitations, which are lack of controllability and flexibility, and lack of reality due to the inability to give a dynamic image. Actually, dynamic representation of facial expressions is necessary because it is more effective to be recognized.

Objectives

The objectives of this study were to propose a method in order to present dynamic facial expressions having various intensity, to investigate human's perception to avatar's facial expressions divided by gradual strength, to investigate how the perception varies to the strength of facial expression, as well as to investigate how different the perception according to avatar's gender.

Method/Tools

For accomplishing these goals, we generated a male and a female virtual avatar with five levels of strength of happy and anger emotion using morphing technique, recruited 16 healthy and normal subjects and measuring the subject's affected emotion by rating affective arousal and valence. The presentation of expressions of virtual faces was not just to show a still image but to show an animation in order for the subject to recognize the avatar's facial expression more realistically. Therefore, we made a virtual avatar animate so that subjects could see a facial animation changing from neutral into a target expression for one second, subsequently they could see the target expression (one of five levels) for 5 seconds. Then, they scored the emo-

tional valence or arousal for the stimulus while being shown a black screen for 5 seconds. The 24 facial expressions of avatars were provided in random order.

Results

In this study, we were able to investigate the human's perceptual characteristics evoked by a male and a female avatar's facial expression of happy and anger, and avatar's gradual facial expression. In addition, we were able to know that the virtual avatar's facial expression could affect human's emotion and it showed different characteristics varied with avatar's gender and the strengths of the facial expressions as well as those characteristics observed in previous studies using photos or video clips. However, we could also see that virtual face have some limitations because it is not real, so subjects were not influenced as much as they recognized the virtual faces.

Conclusion

This study was meaningful in that it could provide new potential for using or manipulating emotional intensity by controlling a virtual avatar's facial expression linearly using a morphing technique, although a virtual avatar has some limitation to convey its emotion using facial expressions. Therefore, it is predicted to be used for assessing emotional characteristics with emotional deficit through a presentation of dynamic expression having various emotional intensities.

Contact:
Jeonghun Ku
133-605 Dept. of Biomedical Engineering
Hanyang University,
Sung Dong P.O. Box 55
Seoul, Korea,
Tel : +82-2-2290-0693
Fax : +82-2-2296-5943
Email: kujh@bme.hanyang.ac.kr

Presenter: Jeonghun Ku PhD

EMOTIONAL INVOLVEMENT IN PRESENCE DURING INTERACTING WITH VIRTUAL AVATAR

Jeonghun Ku Ph.D., Won Yong Hahn, M.S., Hee Jeong Jang, B. A., Sung Hyouk Park, M.D., So Young Kim, B.A., Kwang Uk Kim, M.S., Jae Hun Kim, M.S., Jang Han Lee, Ph.D., Chan-Hyung Kim, M.D., Ph.D., Jae Jin Kim, M.D., Ph.D., In Y. Kim, M.D., Ph.D. and Sun I. Kim, Ph.D.

Dept. of Biomedical Engineering, Hanyang University, Seoul, Korea

Background

Technological advances make virtual reality (VR) able to provide social events by being populated with avatars. Several studies represented that the avatar's representation could influence people's sense of social realism. As one of the critical components to evaluate the effectiveness of virtual environment for the social interaction, the concept of presence has been used. However, there are few studies on how emotion works in the 'feeling of presence' during experiences with virtual societies, although emotion plays an important role in social interaction.

Objectives

It focuses on the impact of avatar's emotions (Happy, Angry, and Neutral Emotion) in co-presence, social presence, and tele-presence. Specifically, we hypothesize that presence, particularly tele-presence, will occur within immersive virtual environments as a function of intensity of emotion. Therefore, we tried to evaluate the presence produced by emotional value of virtual avatars in virtual environments in this study.

Media/Tools

A total of fifteen healthy subjects were recruited for this study. 2 × 3 (avatar gender, avatar emotion) mixed ANOVA experimental design was used for this experiment. All six avatars have emotional appearance, behaviour, and voice. Each participant experienced all 6 tasks (avatar gender × avatar emotion) in a random order. Each task was to be introduced with an avatar and then to introduce oneself to the avatar. After participating, subjects should complete a presence questionnaire and answer the arousal (relax: 0 – excitation: 8) and valence (unpleasant: -4 – pleasant: +4) induced by the experience.

Results

In an investigation of self-reported co-presence and perceived other's copresence, the scores of both co-presence scales to

happy emotional avatar were highest, and the scores to neutral emotional avatar were next, and the scores to angry emotion avatar was lowest (main effect : $p<0.001$). For social presence score, the significant main effect was also observed ($p=0.003$). And, the score to happy emotional avatar was significantly high to Neutral ($p=0.001$), and to Angry avatar ($p=0.007$). The scores of tele-presence to happy emotional avatar ($p=0.014$) and angry emotional avatar ($p=0.046$) were more significantly higher than the score to neutral emotion avatar.

In the results of correlation analysis between emotional value (arousal and valence) and presence score, the correlations between valence and self-reported co-presence ($r=0.873$, $p<0.001$) and perceived others co-presence ($r=0.887$, $p<0.001$) were significant, and the correlation between tele-presence and absolute value of valence ($r=0.327$, $p=0.002$) and value of arousal ($r=0.228$, $p=0.031$) was also statically significant. Also, the correlation between social presence and absolute value of valence was statically significant ($r=0.210$, $p=0.047$).

Discussion

The pattern of self-reported copresence and perceived other's copresence to the avatar's emotional expression was similar. It is probably due to the fact that the questionnaires mostly include factors regarding intimacy and involvement, which are highly related to emotional valence. On the other side, the social presence and tele-presence score showed a high correlation with absolute value of valence. It might mean that humans feel greater presence when the other expresses emotion regardless of positive and negative. Therefore, we could conclude that emotion is an important factor to evoke 'feeling presence' in virtual environments with avatars.

Contact:
Jeonghun Ku
133-605 Dept. of Biomedical Engineering
Hanyang University,
Sung Dong P.O. Box 55
Seoul, Korea,
Tel : +82-2-2290-0693
Fax : +82-2-2296-5943
Email: kujh@bme.hanyang.ac.kr

Presenter: Jeonghun Ku PhD

DEVELOPMENT OF AVATAR FOR MEASURING HUMAN'S SOCIAL EMOTIONAL RESPONSE IN IMMERSIVE VIRTUAL ENVIRONMENT

Jeonghun Ku Ph.D., Won Yong Hahn, M.S., Hee Jeong Jang, B. A., Sung Hyouk Park, M.D., So Young Kim, B.A., Kwang Uk Kim, M.S., Jae Hun Kim, M.S., Jang Han Lee, Ph.D., Chan-Hyung Kim, M.D., Ph.D., Jae Jin Kim, M.D., Ph.D., In Y. Kim, M.D., Ph.D., and Sun I. Kim, Ph.D.

Dept. of Biomedical Engineering, Hanyang University, Seoul, Korea

Background

Virtual reality (VR) has become a representative method or tool to intervene between human and computer. It has been widely used in various fields including medical field, particularly for treating people with mental disease and training handicapped people. It is because VR has the ability to provide us a well controlled environment as well as a realistic, interactive, and immersive environment. Nowadays, an idea has emerged, which social stimuli also could be generated using VR technique, particularly using avatars. This idea has been realized and utilized for people with social anxiety. However, there is lack of evidence whether a virtual avatar could influence human behaviour and emotion. Therefore, the goal of this study was to develop a virtual avatar and to investigate human's behavioural and emotional response in order to examine the possibility to apply it to patients with schizophrenia.

Method/Tools

A male and a female virtual avatar having emotional expressions (happy, neutral, or anger) were designed. The arousal & valence of each avatar's facial expression was matched to the same level based on results of a previous study. For the experiment, 2 × 3 (avatar's gender and avatar's emotion) ANOVA experimental design was used. For the experiment, fifteen healthy subjects were recruited. Each participant experienced all 6 introduction tasks (avatar gender × avatar emotion) in random order. As measurements for this study, behavioural response (interpersonal distance defined as a distance between a subject and an avatar), emotional

(arousal and valence) measurements, and recalled memory score were acquired.

Results

Through this study, we were able to observe that an avatar expressing emotion could influence human behaviour, emotion, and memory. In detail, when the interpersonal distance was compared in each condition, the significant main effect to avatar's gender was observed (p=0.023), while the difference according to avatar's gender at each emotional expression was not significant. In addition, further distance was set in case of being presented with an angry avatar regardless of avatar's gender (happy vs angry : p=0.006/ neutral vs angry : p=0.003). In summary, humans keep the interpersonal distance closer to female avatar than to male avatars and further from an avatar representing angry emotion than to an avatar representing neutral or happy emotion. Furthermore, subjects recalled more correctly in a condition having an angry avatar than in a neutral avatar condition (p=0.006). However, in the case of being provided an avatar representing happiness, a higher mean score was shown but was not significant (p=0.108).

Conclusion

These results support that the virtual avatar could influence human behaviour, emotion, and memory, in particular, that those characteristics were varied by emotional expressions of the virtual avatar. The characteristics resulting from this study coincided with studies conducted with real people or other instruments. A virtual reality and virtual avatar could draw human behavioural and emotional characteristics and assess those objectively. Therefore, it could provide a potential to be used for assessing human's characteristics as well as assessing and enhancing social ability of a person who has social function deficits, e.g., schizophrenia, using virtual avatars.

Contact:
Jeonghun Ku
133-605 Dept. of Biomedical Engineering
Hanyang University,
Sung Dong P.O. Box 55
Seoul, Korea,
Tel : +82-2-2290-0693
Fax : +82-2-2296-5943
Email: kujh@bme.hanyang.ac.kr

Presenter: Damini Kumar

WEARABLE KINEMATIC AND PHYSIOLOGICAL BIOFEEDBACK SYSTEM FOR MOVEMENT-BASED RELAXATION

Damini Kumar MSc, John Foody; Brian Caulfield; Tomas Ward; Charles Markham

University College Dublin

In this project we are developing an effective feedback system for a human interface with a video game designed to promote mental and physical relaxation. Therapies such as Tai Chi and Yoga have been shown to have many therapeutic benefits in rehabilitation including enhancing postural awareness and reducing chronic pain and hypertension.

We aim to develop a computer game in which the player's performance is determined by their ability to master one of these physical arts and in doing so bring about a state of mental relaxation. We are developing a virtual reality application where whole-body movement, respiration and physiological correlates of relaxation are used as input. Such input will be processed to provide changes to the avatar or its environment in order to affect appropriate biofeedback for the user. The purpose of this biofeedback is such that they may more easily achieve targeted postures and physiological variable ranges commensurate with Yoga/Tai Chi philosophy.

A garment based physiological and kinematics measurement system will provide our primary method of communication with the video game. This lightweight garment will monitor heart and breathing rate, muscle activity, galvanic skin response, and alignment of body segments. To measure the human body motion we have designed and implemented a Universal Serial Bus (USB) based unobtrusive kinematics transducer capable of scalable deployment with minimum instrumentation.

The player must reproduce physical postures displayed by a model on screen whilst maintaining a relaxed and controlled breathing pattern. Feedback is provided by means of reproduction of the player's body image on screen. Quality of movement and posture,

and degree of mental relaxation will determine the player's performance. The game could take the form of a track and field decathlon format. This system could benefit patients suffering from many conditions including hypertension, anxiety disorder, and chronic pain.

References

1.Tran MD, Holly RG, Lashbrook J, Amsterdam EA. Effects of Hatha yoga practice on the health related aspects of physical fitness. Prev Cardiology 2001; 4: 165-70

2. David Fontaine, David Dominique - "Sourceless Human Body Motion Capture"- SOC Grenoble 2003.

Contact:
Damini Kumar MSc
University College Dublin
School of Physiotherapy, Health Sciences Building, University College Dublin, Belfield
Dublin 4, Ireland
Tel: 00353861725625
Fax: 00441895812446
Email: damini.kumar@ucd.ie

Presenter: Belinda Lange

THE EFFECTIVENESS OF VIRTUAL REALITY IN REDUCING PAIN AND ANXIETY DURING DIGITAL NERVE BLOCK

Belinda Lange (PhD candidate) BSc, B Physio (Hons), Marie T Williams, Sara Jones

University of South Australia

Background

Applications of Virtual reality (VR) as a distraction technique have included situations requiring medical procedure for an injury/ ailment. Common invasive procedures (injections/venipuncture) involve the learner practicing the task. Some health training programs offer students the opportunity to learn invasive techniques on each other prior to performing them in therapeutic situations. The aim of this study was to determine if VR was effective in reducing pain and anxiety in students receiving a digital nerve block from their peers as part of a teaching program.

Method/tools

A randomized controlled trial was used. Podiatry undergraduates were randomly assigned to receive the procedure whilst immersed in VR (Group A=VR) or verbally distracted (Group B=control). Pre and post outcome measures included VAS(pain), State-Trait anxiety inventory (STAI), and simulator sickness questionnaire (SSQ). Blood pressure (BP), heart rate (HR), skin conductance (SC), and malaise scale (MS) were measured pre, during, and post procedure. Within-group and between-group analyses were performed.

Results

There were no significant differences in demographics between groups. No significant difference was found between groups for VAS for pain ($p=0.78$). Compared to baseline levels, SC was significantly higher during the procedure in the control group ($p<0.001$). State STAI significantly decreased in both groups following the procedure (Group A $p=0.01$; Group B $p=0.008$) and no difference was evident between groups (pre ($p=0.124$), post ($p=0.065$) procedure). Two subjects reported symptoms (MS) when immersed in VR. There was no significant difference between pre/post SSQ in the VR group. Diastolic BP was significantly lower ($p=0.034$) and HR significantly higher ($p=0.042$) in the VR group. Novelty/ discussion: To date the majority of studies investigating the use of VR as a distraction technique have concentrated on medical procedures with high pain levels. Pain associated with injections is comparatively low, however often associated with high anxiety levels. No significant difference in subjective pain may be a result of the action of local anaesthetic, numbing the area after needle insertion. The significant increase in SC during the control condition only ($p<0.001$) suggests that, despite the presence of local anaesthetic, anticipatory anxiety was high when the procedure was viewed, compared to distraction with VR ($p>0.056$). STAI results are possibly due to an ordering effect; the majority of group A subjects received the procedure then performed the procedure on another student. Malaise scale results indicate that adverse effects occurred in two subjects. No significant change in SSQ scores for the VR group supports MS findings. However, pre and post SSQ scores were high for both groups, including the control group where SSQ scores should be zero since subjects

were not exposed to VR, suggesting that SSQ may be associated with procedural anxiety and not adverse VR symptoms. Significant BP and HR changes during VR reflect the physical activity involved in the intervention.

Conclusion: While VR did not significantly influence subjective pain scores, lower SC indicates that VR reduced anticipatory anxiety associated with the procedure. The MS may be a more appropriate measure of adverse effects than the SSQ in situations where high levels of anxiety exist.

References

Hoffman HG, Doctor JN, Patterson DR, Carrougher GJ, Furness TA. Virtual reality as an adjunctive pain control during burn wound care in adolescent patients. Pain 2000b; 85:305-309.

Hoffman HG, Garcia-Palacios A, Patterson DR, Jensen M, Furness TA, Ammons WF. The effectiveness of virtual reality for dental pain control: a case study. CyberPsychology & Behaviour 2001b; 4:527-535.

Hoffman HG, Patterson DR, Carrougher GJ. Use of virtual reality for adjunctive treatment of adult burn pain during physical therapy: a controlled study. Clin J Pain 2000a; 16:244-250.

Hoffman HG, Patterson DR, Carrougher GJ, Nakamura D, Moore M, Garcia-Palacios A, Furness TA. The effectiveness of virtual reality pain control with multiple treatments of longer durations: a case study. Int. J. Hum.-Comput. Interact., 2001a; 13:1-12.

Kennedy RS, Lane NB, Berbaum KS, Lilienthal MG. Simulator sickness questionnaire: an enhanced method for quantifying simulator sickness. The Int J Aviat Psychol 1993; 3:203-220.

Regan EC, Ramsey AD. The efficacy of hyoscine hydrobromide in reducing side-effects induced during immersion in virtual reality. Aviat Space Environ Med 1996; 67:222-226.

Spielberger CD. Stait-Trait Anxiety Inventory (Form Y). California: Mind Garden, Inc.; 1983. p 13.

Steele E, Grimmer K, Thomas B, Mulley B, Fulton I, Hoffman HG. Virtual reality as a pediatric pain modulation technique: A case study.
CyberPsychol Behav 2003; 6:633-638.

Contact:
Belinda Lange
University of South Australia
North Terrace Adelaide
Adelaide, SA 5000
Australia
Phone: 011 61 8 83022083
Fax: 011 61 8 83022766
Email:
Belinda.Lange@postgrads.unisa.edu.au

Presenter: Belinda Lange

SUBJECTIVE, PHYSIOLOGICAL AND ADVERSE EFFECTS OF THE VIRTUAL REALITY ARQUAKE GAME COMPARED TO WATCHING AN ANIMATED MOVIE IN CHILDREN AGED 6-17 YEARS

Belinda Lange (PhD candidate) BSc, Marie T Williams, Ian Fulton, Meredith Craigie, & Bruce Thomas

University of South Australia

Background

The Virtual reality (VR) ARQuake game was developed at the Wearable Computer Laboratory (UniSA) and is currently being used by researchers as a distraction technique for children undergoing painful procedures. This study was designed to understand how children react to VR, when not undergoing painful situations. The aim of the study was to compare the subjective, physiological and adverse responses of children to the VR ARQuake game with an animated movie.

Method/tools

A randomized AB/BA crossover design was used. Subjects aged between 6-17 years were randomly assigned to 14 minutes of VR and a 14 minute section of an animated movie in varying order (Group A=VR/movie; group B=movie/VR). The simulator sickness questionnaire (SSQ) was completed pre and post procedure. Blood pressure (BP), heart rate (HR), skin conductance (SC), and malaise scale (MS) were measured pre, during, and post procedure. Subjects completed a presence questionnaire (PQ) following both VR and movie.

Results

Thirty-six subjects were recruited (21 males and 15 females, mean age 11.89±2.98). Sub-

ject numbers were equal in both groups. No significant difference was found in demographic details between groups. Significant treatment effects were present for the level of enjoyment of the game (PQ) ($p=0.03$) and SSQ ($p<0.0001$). No significant period-by-treatment interaction was present for any outcome measures ($p>0.05$). The level of presence (PQ) was significantly higher during VR ($p<0.004$). No significant difference in SC between VR and movie (>0.051) occurred at any time point. Blood pressure and HR were significantly higher during VR ($p<0.014$), however no significant difference in BP and HR was present post 5 minutes ($p>0.481$). Symptoms (e.g., HMD heavy, dizziness) were reported during VR on the MS by 47% of subjects, compared to 3% during the movie. Mild nausea was reported by 6% of subjects during VR (0% movie). Subjects reported no symptoms 5 minutes post VR.

Novelty/ discussion

The VR ARQuake game demonstrated higher levels of presence than the movie with subjects reporting significantly higher scores in the PQ (felt like they were really there; felt like they were actually moving; game was more difficult and harder to get used to). These results indicate that VR will be an effective distraction
technique during painful procedures because of the higher level of presence and greater level of concentration required. Although greater symptoms were reported on the MS during VR, only 6% reported mild nausea and all symptoms subsided within five minutes. It appears that the MS is a more appropriate indicator of adverse responses to VR than SSQ in children, possibly as a result of the wording on the SSQ. The non-significant SC result between VR and movie supports the MS findings. The significant increase in BP and HR during VR reflect the physical activity involved in interacting with the virtual environment.

Conclusion

This study provides more information about the physiological and adverse effects of VR in children and provides support for the use of the VR ARQuake game in children undergoing painful and anxiety provoking procedures provided a malaise scale is used to monitor nausea.

References

Kennedy RS, Lane NB, Berbaum KS, Lilienthal MG. Simulator sickness questionnaire: an enhanced method for quantifying simulator sickness. The Int J Aviat Psychol 1993; 3:203-220.

Regan EC, Ramsey AD. The efficacy of hyoscine hydrobromide in reducing side-effects induced during immersion in virtual reality. Aviat Space Environ Med 1996; 67:222-226.

Contact:
Belinda Lange
University of South Australia
North Terrace Adelaide
Adelaide, SA 5000
Australia
Phone: 011 61 8 83022083
Fax: 011 61 8 83022766
Email:
Belinda.Lange@postgrads.unisa.edu.au

Presenter: Belinda Lange

VIRTUAL REALITY AS A DISTRACTION TECHNIQUE FOR CHILDREN DURING MINOR MEDICAL PROCEDURES IN A PEDIATRIC EMERGENCY DEPARTMENT

Belinda Lange PhD candidate, Marie Williams, Ian Fulton, Meredith Craigie

University of South Australia

The aim of this study was to determine if Virtual Reality is an effective distraction technique for children undergoing minor medical procedures in a Paediatric Emergency Department compared to watching a movie. Children between 6-17 years undergoing minor medical procedures such as blood sampling, intravenous cannulae insertion and suturing were provided with either Virtual reality or an animated movie excerpt as a distraction technique during the procedure. Pre, post and maximum scores were received for children's self report pain and anxiety and parent's perception of their child's pain and anxiety. Staff members were asked to provide a score for their perception of the child's pain and anxiety. Parental anxiety was also measured for comparison with the child's anxiety levels. The brief behavioral distress scale was used to score the child's

behavior during the procedure. Data collection for this study is still ongoing and is anticipated to be completed by June 2005. To date, twenty-two subjects have been recruited with a target of at least 100 subjects. The two interventions (Virtual reality and animated movie) will be compared using mixed between-within subjects analysis of variance and independent t tests. Baseline pain and anxiety data for these procedures was collected in a separate study, providing information about the pain and anxiety associated with these procedures without distraction. Pilot testing comparing the level of presence and enjoyment of the Virtual reality to watching an animated movie in healthy children not undergoing procedures has also been completed. If Virtual reality is found to significantly reduce pain and anxiety in children during minor medical procedures compared to watching an animated movie, the technique may be employed by the Pediatric Emergency Department as a non pharmacological pain management tool.

Contact:
Belinda Lange
University of South Australia
North Terrace Adelaide
Adelaide, SA 5000
Australia
Phone: 011 61 8 83022083
Fax: 011 61 8 83022766
Email:
Belinda.Lange@postgrads.unisa.edu.au

Presenter: Jang-Han Lee PhD

SPATIAL ABILITY AND NAVIGATION LEARNING IN A VIRTUAL CITY

Richard Mraz, P.Eng.[2], Konstantine K. Zakzanis, Ph.D., C.Psych.[3], Peter J. Snyder, Ph.D.[4] In Y. Kim, Ph.D.[1], Sun I. Kim, Ph.D.[1], Sandra E. Black, M.D.[5], Simon J. Graham, Ph.D., .Eng.[2,6]

[1] Department of Biomedical Engineering, Hanyang University, Seoul, Korea
[2] Imaging Research, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada
[3] Division of Life Sciences, University of Toronto, Toronto, Ontario, Canada
[4] Department of Psychology, University of Connecticut, Groton, CT, USA
[5] Department of Medicine-Neurology, University of Toronto, Toronto, Ontario, Canada
[6] Department of Medical Biophysics, University of Toronto, Toronto, Ontario, Canada

Research Status: Completed

Background & Significance of the Problem

Virtual environments (VEs) can be used to assess spatial memory and navigation skills, although the behaviour elicited is inherently complex. The purpose of this study was to investigate the ecological validity and interrelationship between virtual navigation tasks and several neuropsychological tests.

Methods/Tools

Forty-two participants (mean age: 70.42) took part in the study, of which eighteen were recruited from the Cognitive Neurology Clinic at Sunnybrook & Women's College Health Sciences Centre (S&W) based on diagnosis of mild cognitive impairment (MCI). Subjects completed the Groton Maze Learning Test (GMLT; a hidden maze task developed by one of the authors [P.J.S.]) and several neuropsychological tests, including the MMSE,[1] the Rey Complex Figure Test,[2] Benton Visual Retention test,[3] Trail-Making Test (Forms A and B),[4] and Digit Span.[5] Sixteen of the participants (9 normal, 7 MCI) also undertook a VE navigation task.[6] Behaviour elicited by the VE task was characterized in terms of two components, as estimated by factor analysis: a VE memory index, and a VE movement index.

Results

The VE memory index was significantly associated with the results of a conventional memory test (Rey Complex Figure), and the VE movement index was significantly associated with measures of the Trail Making Test. Compared with normal participants, participants with mild cognitive impairment (MCI) showed a significant reduction in the memory-related measures in the PGRD Maze Learning Test and memory tests (particularly RCFT), and the MCI group deviated significantly from the correct route, particularly in novel environments. Performance in the VE navigation-learning task was significantly associated with measures of visual memory and the executive function in conventional neuropsychological tests.

Conclusion

The results of this study demonstrate that VE technology can be used to assess spatial memory and navigation skills, and that measures of this behavior in a VE are related to those of conventional neuropsychological tests. Our results also demonstrate that the MCI group showed a significant reduction in memory-related measures in the GMLT and the neuropsychological tests. In particular, differences between the groups were evident in the immediate and delayed recall in the Rey Test. However, because of the small sample size, statistically significant results were not found between groups in the VE navigation task.

Novelty

The interrelationship between the VE task, the GMLT, and neuropsychological assessments is important for administration and interpretation of these computerized tests in the future.

References

[1] Folstein, M.F. et al. (1975). Journal of Psychiatry Research, 12, 189-198.
[2] Meyers, J.E., & Meyers, K.R. (1995). Rey Complex Figure Test and Recognition Trial: Professional Manual. Odessa, FL: PAR
[3] Sivan, A.B. (1992). Benton Visual Retention Test: Fifth Edition. San Antonio, TX: Psychological Corporation.
[4] Spreen, O., & Strauss, E. (1998). A Compendium of Neuropsychological Tests: Administration, Norms, and Commentary (2nd ed.). New York: Oxford University Press.
[5] Wechsler, D. (1981). Wechsler Adult Intelligence Scale-Revised Manual. San Antonio, TX: The Psychological Corporation.
[6] Mraz, R. et al. (2003). CyberPsychology & Behavior, 6(4), 359-368.

Contact:
Jang-Han Lee, Ph.D.
Department of Biomedical Engineering
College of Medicine
Hanyang University
Seoul, Korea
TEL: +82-2-2290-8280
FAX: +82-2-2296-5943
Email: clipsy@unitel.co.kr

Presenter: Jang-Han Lee PhD

THE APPLICATION OF A VR-TANGIBLE INTERACTION SYSTEM IN SENSORY INTEGRATION TRAINING AND ASSESSMENT FOR CHILDREN WITH AUTISM

Jang-Han Lee, Ph.D.[1], Hyun-Jhin Lee, M.Sc.[2], Young Sik Lee, M.D.,Ph.D.[3], Seong-shim Cheong, M.D.,Ph.D.[4], Kwang B. Park, Ph.D.[5]

[1] Department of Biomedical Engineering, College of Medicine, Hanyang University, Seoul, Korea
[2] School of Design and Media, Hongik University, Seoul, Korea
[3] Department of Neuropsychiatry, College of Medicine, Chung-Ang University, Seoul, Korea
[4] Seoul Metropolitan Children's Hospital, Seoul, Korea
[5] Department of Psychology, Chungbuk National University, Seoul, Korea

Research status: Still in progress

Children with autism, as well as children with other developmental disabilities, may have dysfunctional sensory systems. Sometimes one or more senses are either over- or under-reactive to stimulation in these individuals. Sensory processing abnormalities affect all aspects of adaptive, cognitive, social, and academic functioning, and correlate with higher levels of stereotypic, rigid, and repetitive behaviours in autism. Thus, sensory processing abnormalities may be important to address in therapeutic interventions that aim to reduce rigidity and stereotyped behaviours. Sensory integration therapy is based on a theory developed by Ayres (1972), which emphasizes the relationship between sensory experiences and motor and behavioural performance. Intervention strategies involve the use of planned and controlled sensory experiences, including vestibular, proprioceptive, and somatosensory activities, such as swinging, deep pressure touch, and tactile stimulation; that is, the techniques facilitate attention and awareness, and reduce overall arousal of children with autism.

Virtual reality technology is an exciting tool for allowing children with autism to practice behaviours in role-play situations, while providing a safe environment for rule learning and repetition of tasks (Parsons & Mitchell, 2002). However, some ethical and technical concerns surround the use of fully immersive virtual reality technology (i.e., the use of head-mounted displays (HMDs)). HMDs can

be extremely expensive and people may experience 'cybersickness' in the form of nausea, headache, and dizziness, whereas desktop or projection virtual environments tend to be much less likely to induce cybersickness. Moreover, because HMDs place some limitations on the child's interaction with another person, the mixed and augmented reality is more useful for group interactions and sensory experiences.

Therefore, we developed a virtual reality–tangible (VR–tangible) interaction system for sensory integration training and assessment of autism by mixing the virtual environment with the natural physical environment. With this system, children with autism experience vestibular, proprioceptive, and somatosensory activities, such as swinging, spinning, and rotating, and a social skills training program such as eye gaze. In addition, a program that involves breaking virtual balloons with a real stick measures the visuomotor coordination of children with autism. The participants view themselves, virtual balloons, and a real stick on a large screen that displays game-like scenarios. Our VR–tangible interaction system consists of a Pentium IV PC, a projector, a screen (200 × 150 cm), an infrared reflector, and a digital camera.

The performances of normal control groups and autistic groups will be compared in the visuomotor coordination program and the social skills training program. The degree that the sensory integration training leads autistic children to more productive contacts with another individual and environments will also be analyzed.

As the study is still in progress, final results were not available at the time this abstract was written. The use of a VR–tangible interaction system to better understand sensory processing abnormalities of children with autism is relatively rare, even in studies with virtual environments. We hope that this study will clarify sensory processing abnormalities of children with autism and stimulate further studies on sensory integration training and assessment in the field of VR–tangible interaction.

References

Ayres, J. (1972). Improving academic scores through sensory integration. *Journal of Learning Disabilities, 5*, 338-343.

Parsons, S., & Mitchell, P. (2002). The potential of virtual reality in social skills training for people with autistic spectrum disorders. *Journal of Intellectual Disability Research, 46(5)*, 430-443.

Contact:
Jang-Han Lee, Ph.D.
Department of Biomedical Engineering
College of Medicine
Hanyang University
Seoul, Korea
TEL: +82-2-2290-8280
FAX: +82-2-2296-5943
Email: clipsy@unitel.co.kr

Presenter: Jang-Han Lee PhD

SEX DIFFERENCES IN HEALTHY ELDERLY ADULTS FOR COMPLETING 2-DIMENSIONAL HIDDEN MAZE AND 3-DIMENSIONAL VIRTUAL REALITY NAVIGATION LEARNING TASKS

Jang-Han Lee PhD[1], Richard Mraz, P.Eng.[2]
Konstantine K. Zakzanis, Ph.D., C.Psych.[3]
Peter J. Snyder, Ph.D.[2], In Y. Kim, Ph.D.[1]
Sun I. Kim, Ph.D.[1], Sandra E. Black, M.D.[2]
Simon J. Graham, Ph.D., P.Eng.[2]

[1]Hanyang University, Seoul, Korea
[2]Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada
[3]University of Toronto, Toronto, Ontario, Canada
[4]University of Connecticut, Groton, CT, USA

Background & Significance of the Problem

Sex differences in navigation and maze learning are well known, with men often outperforming women on route-learning, spatial perception, and visualization.[1-4] Some suggest that these differences stem from evolution, while others attempt to further elucidate these differences by new experimental methods. The present study used a series of nonverbal, visually-guided navigation tasks to investigate gender differences in healthy, elderly adults.

Methods/Tools

The three distinct test components were 1) the Groton Maze Learning Test (GMLT), 2) traditional neuropsychological tests, and 3) a 3D VE navigation-learning task. The GMLT is a computerized measure of a participant's

ability to acquire and use efficiently an internal spatial map of a hidden 2D maze. Neuropsychological tests included the MMSE,[5] the Rey Complex Figure Test,[6] Benton Visual Retention test,[7] Trail-Making Test,[8] and Digit Span.[9] The 3D VE navigation task[10] involves learning and recalling routes through a virtual city. Twenty-five healthy elderly volunteers participated.

Results

Sex differences were found in learning ability with the 2D maze test and the VE navigation. Men excelled at maze-learning ability, especially after the middle trials, although men and women did not differ in performance on the first learning trial for this test. These results suggest that men more easily acquired spatial ability and learning than women, and that men also reached their peak performance ability more rapidly than women in the maze-learning test.

Men significantly outperformed the women only on the first trial of the VE navigation task. There were no sex differences after a second trial, perhaps due to the relative ease of the VE navigation task since no subjects deviated significantly from the path following the second learning trial.

Performance on the GMLT was related to performance on both the memory-related neuropsychological tests and the VE task.

Conclusion

Men outperform women on the 2D and 3D navigation tasks. Future studies should investigate sex differences between topographic and Euclidian cues in VE navigation learning and how these strategies and age affect spatial memory and navigation learning in normal people.

Novelty

This study suggests that the VE task has ecological and comparative validity for measuring spatial ability and navigation.

References

[1] Galea, L.A., & Kimura, D. (1993). *Personality and Individual Differences,* 14, 53–65.
[2] Holding, C.S., & Holding, D.H. (1989). *Journal of General Psychology, 116,* 29–41.
[3] Moffat, S.D. et al. (2001). *Neurobiology of Aging,* 22, 787-796.
[4] Sandstrom et al. (1998). *Cognitive Brain Research, 6,* 351–360.
[5] Folstein, M.F. et al. (1975). *Journal of Psychiatry Research, 12,* 189-198.
[6] Meyers, J.E., & Meyers, K.R. (1995). *Rey Complex Figure Test and Recognition Trial.* Odessa, FL: PAR
[7] Sivan, A.B. (1992). *Benton Visual Retention Test.* San Antonio, TX: Psychological Corporation.
[8] Spreen, O., & Strauss, E. (1998). *A Compendium of Neuropsychological Tests.* New York: Oxford University Press.
[9] Wechsler, D. (1981). *Wechsler Adult Intelligence Scale-Revised Manual.* San Antonio, TX: The Psychological Corporation.
[10] Mraz, R. et al. (2003). *CyberPsychology & Behavior, 6(4),* 359-368.

Contact:
Jang-Han Lee, Ph.D.
Department of Biomedical Engineering
College of Medicine
Hanyang University
Seoul, Korea
TEL: +82-2-2290-8280
FAX: +82-2-2296-5943
Email: clipsy@unitel.co.kr

Presenter: Elizabeth Lewis M.R.C.Psych

WHAT ASPECTS OF VIRTUAL ENVIRONMENTS MAKES THE EXPERIENCE "REAL" FOR AGORAPHOBIC PATIENTS?

David.G.Walshe[1], Elizabeth J. Lewis[2]

[1] St. Stephen's Hospital, Cork, Ireland., Department of Psychiatry, University College Cork.
[2] St. Stephen's Hospital, Cork, Ireland. Department of Child Health and Paediatrics, University College Cork

Research Status: Research in progress

Agoraphobia with or without panic disorder is a disabling mental health problem with an estimated population prevalence of 6%. It is frequently seen in both primary and secondary mental health settings. Currently, although the evidence base for behaviour therapy for agoraphobia is extensive, the service delivery is poor. It is estimated that 25% of phobic patients refuse "in vivo" exposure

therapy or drop out. Consequently behaviour therapy is often difficult to provide in this area.

Preliminary studies have shown a role for virtual reality (VR) in the treatment of agoraphobia. Vincelli et al. showed significant reductions in the number of panic attacks, level of depression and both state and trait anxiety following VR treatment with Experiental Cognitive Therapy (ECT).[1] Botella et al showed VR exposure therapy as effective as in vivo exposure in a number of outcome measures including fear, avoidance and panic symptoms.[2]

In this study of 5 agoraphobic patients we investigated what aspects of virtual environments induce presence in agoraphobic patients using *VRMRI Virtual World* software by Psychology *Software Tools, Inc.* This software provides 13 inter-connected VR environments which include: an urban area, apartment, theatre complex, restaurant, bank, urban subway station, village subway station, village area, house, doctor's office, airport subway station, and two airports).

We examined which environments induced presence with associated subjective distress and physiological anxiety and whether the addition of background sounds pertinent to each environment influenced presence and distress
levels.

Procedure

5 subjects with DSM-IV criteria either for agoraphobia without history of panic disorder or panic disorder with agoraphobia were initially exposed to a neutral VR environment to acclimatise to VR. Thereafter patients navigated virtual environments with or without the addition of background sound over a 3 minute period unless anxiety symptoms necessitated termination of exposure.

Ratings of presence (Item from Presence Inventory), subjective distress (SUDS) and physiological anxiety (Heart Rate measurements) were recorded once per minute during exposure to each environment and verbal feedback from each patient following each exposure was recorded.

Results

This study is ongoing. Results will be presented at conference together with VR environments.

Novelty

VRET for agoraphobia is at a developmental stage. Information from this study will assist in tailoring VR software and treatment programs.

Contact:
Dr David Walshe
St Stephens Hospital
Sarsfield Court
Cork
Tel: 00-353-21-48214211
Email: davidgmw@yahoo.com

Presenter: Elizabeth Lewis M.R.C.Psych

IS VIDEO HOMEWORK OF BENEFIT WHEN PATIENTS DON'T RESPOND TO VR THERAPY FOR DRIVING PHOBIA?

David.G.Walshe[1], Elizabeth J. Lewis[2]

[1] St. Stephen's Hospital, Cork, Ireland., Department of Psychiatry, University College Cork.
[2] St. Stephen's Hospital, Cork, Ireland. Department of Child Health and Paediatrics, University College Cork

In our *Virtual Therapy Clinic*, based in Cork, we have specialised in developing and evaluating virtual reality environment treatment (VRET) programmes for driving phobia in motor accident victims. Findings have been reported supporting this treatment modality.[1-3] This patient group often has co-morbid psychiatric conditions including major depression, posttraumatic stress disorder, panic disorder, and substance abuse which complicates treatment.

Our standard driving programme involves 8-12 VR sessions, using computer games with graded driving *in vivo* homework tasks following progress in virtual exposure.

Presently we are focusing on two clinical concerns. Patients who do not desensitise/ reprocess their travel fears despite multiple virtual exposure sessions and the number of treatment sessions required for successful

VR treatment.

Aim

To assess whether the addition of video homework tasks involving exposure to watching video clips of driving situations encountered in VR therapy will bring about desensitization and thereby symptom resolution in patients resistant to VR exposure therapy.

Procedure

3 patients, with a diagnosis of DSM-IV Specific Phobia-driving, resistant to a VR driving programme undertook a "video homework" programme. A video tape containing a 10 minute clip of anxiety provoking driving situations derived from the most recent VR session was assigned as homework. These clips were recorded directly from the VR driving scenes presented in therapy. Each patient was requested to watch the video clip for 30 minutes daily in a darkened room with earphones and record Subjective Units of Distress (SUD) ratings daily until anxiety level fell to SUD rating of 2 or less. As the patient progressed to more distressing driving scenarios in VR therapy the video clip was updated accordingly.

The Fear of Driving Inventory (FDI) and the Posttraumatic Stress Disorder Symptom Scale (PTSS) were documented at entry and reassessed on completion of the study.

Results

This study is ongoing. Results will be presented at conference together with assigned video clips.

Novelty

This is a novel development in VRET with potential clinic benefit.

References

1 Walshe, D.G., Lewis, E.J., Kim, S.I., et al (2003). Virtual Reality and computer games in the treatment of driving phobia induced by a motor vehicle accident. Cybertherapy Conference 2003 p34.

2.Walshe, D.G., Lewis, E.J., Kim, S.I., et al (2003). Exploring the use of computer games and virtual reality exposure therapy for fear of driving following a motor vehicle accident. CyberPsychology & Behavior 6:329-334.

3.Walshe, D.G., Lewis, E., Kim SI, O'Sullivan, K., Virtually driving: Are the driving environments "real enough" for exposure therapy with accident victims? Submitted for publication CyberPsychology & Behavior 2004.

Contact:
Dr David Walshe
St Stephens Hospital
Sarsfield Court
Cork
Tel: 00-353-21-48214211
Email: davidgmw@yahoo.com

Presenter: J. Harvey Magee

A PRIMER ON TATRC'S MEDICAL MODELING & SIMULATION PORTFOLIO: THE SERIOUS SIDE OF FUN

J. Harvey Magee

Portfolio Manager, Medical Modeling & Simulation (MM&S)
Telemedicine and Advanced Technology Research Center (TATRC)
HQ U.S. Army Medical Research and Materiel Command

As we enter the 21st century, the worlds of military and civilian medical training struggle with critical questions. For the military, how do we train medical personnel in peace for the realities of war? For the civilian sector, how do we train medical personnel in a way that results in increased patient safety...or reduced patient errors? Reports from the U.S. General Accounting Office and the Institute of Medicine have dealt with these challenges.

Why serious? Here are a couple of examples. First, health care the power to heal or harm patients. How we train to deliver care is serious too. What if residents actually deliver health care the way we teach them to? Second, the human body is infinitely challenging...and constantly changing. Everybody (literally every body) is different. How much realism is necessary to simulate it? What objective performance metrics are most appropriate? Simulated environments impact people, but in what ways?

In 2000, TATRC MM&S leaders (Dr. Moses, Mr. Magee), facilitated a 70-person strategic planning workshop. At its conclusion and in conjunction with "end users" of simulation-based training systems, a strategy was developed. Based on that strategy, collaborations of academic, government, and industrial research groups began to take shape, and networks of relationships formed. Leaders stepped forward, and funding sources were identified to propel research in four general categories of medical simulation research: PC-based interactive multimedia, digitally enhanced mannequins, part-task trainers, and Total Immersion Virtual Reality. Key defining events and workshops have been funded over the past five years in support of that strategy. Annual refinements of the strategy have been made, always in conjunction with "end users."

Fueled by congressionally designated funded and managed by TATRC, the Center for Integration of Medicine and Innovative Technology (CIMIT) Simulation Group (PI: Dr. Steve Dawson) embraced the challenge to develop and integrate key enabling technologies into systems of simulation-based training. Examples are real-time *in vivo* tissue property measurement, tissue-tool interactions, graphics and visualization, learning systems, metrics development, learning transfer and assessment.

Examples of current projects include advanced ureteroscopic surgical simulation (TURP procedure), virtual cricothyroidotomy, VIRGIL™ Chest Trauma Training System, Central Venous Catheterization, Exsanguinating Hemorrhage, "VR-Demo", Dynamic Injury Creation Simulator.

What degree of validation is necessary to demonstrate transfer-of-training effectiveness? What open source standards require development enroute to the eventual need for systems to be interoperable with either other medical simulation systems or more comprehensive training systems?

In summary, the presenter will predict some benefits of medial simulation, and offer some closing thoughts for success for the MM&S community...and the world.

Presenter: Ralph Mager MD

VIGILANCE AND PERFORMANCE

MEASUREMENTS IN A REAL-CAR BASED DRIVING-SIMULATOR

Dr. Ralph Mager

COAT Basel, Switzerland

Objective

The goal of the present study was to evaluate physiological measures and objective performance parameters during driving in a real-car based driving simulator. Arousing auditory stimuli were applied to compare data prior and after intervention to test the sensitivity of the system.

Design and Methods

Overall 41 subjects were selected matched for age and driving experience. To create realistic traffic scenarios in a laboratory environment a passenger car simulator was used emulating the functionality of a modern car. Electroencephalographic (EEG) activity, skin conductance, respiratory and cardiac parameters were continuously recorded during driving. Analysis was focused on time intervals prior and after application of a warning stimulus intervening a monotonous driving session. Simultaneously objective driving-parameters were derived from the simulator (time to lane crossing, lateral position and others).

Results

The intervening stimuli induced significant group effects in respect to EEG activity and skin conductance. There was a decline of the stimulus induced changes within several minutes. Other physiological parameters like respiratory or cardiac parameters were unaffected. Data revealed a strong inter-individual variability. This applied also to the performance parameters provided by the simulator. Time to lane crossing and the lateral position of the car were determined in different scenarios and separated for various types of tracks.

Conclusion

The present study revealed significant physiological group effects in response to intervening stimuli during driving in a real-car based simulator. EEG effects, simulator data

and first applications in psychiatry are discussed.

Contact:
Dr. Ralph Mager
COAT Basel
Basel, 4025
Switzerland
Phone: 0041613255242
Fax: 0041613255492
Email: ram@coat-basel.com

Presenter: Mark Matthews MSc

WIRELESS THERAPY: MOBILE GAMES AS A MEANS OF ENGAGING ADOLESCENT CLIENTS

Mark, Matthews BA, M. Sc.[1], Dr. Gavin Doherty[1], Dr. John Sharry[2]

[1] Trinity College Dublin, Ireland
[2] Mater Hospital, Dublin, Ireland

Research Status: Currently in progress.

Therapists have difficulties engaging adolescent clients in therapeutic activities between sessions. These activities usually require clients to prepare materials in advance of sessions or chart their feelings between them. Typically there is a very low rate of task completion in these activities. This might be attributed to the use of outmoded materials or methods which are not concurrent with adolescent interests.

Research suggests that client-centered materials have a greater chance of success in engaging adolescent clients. Mobile gaming represents such an approach, allowing access to adolescents' personal space, but affording adolescent users persistent and continual access to therapeutic materials. Most importantly it takes advantage of an existent widespread network in use by adolescents and therefore requires no extra hardware costs. The proposed system will allow therapists to send personalised game missions to clients' phones at specific agreed times between sessions. After each level the client will receive a positive personal message from the therapist. The proposed game will be similar to the shoot-em-up genre of mobile game. During a session clients' phones will synchronise with therapists' computers during sessions and allow therapists and clients to view and discuss the game information.

Trials of this system will be run in the Mater Hospital and several of its associated clinics in Dublin. Research conclusions will be made as a result of pre- and post- questionnaires for therapists and clients, detailed interviews with therapists, client attendance records, and log data from client's mobile games. A comparative study of mobile games versus current materials and approaches will also be undertaken.

It is hoped that this research will ascertain whether mobile games can: effectively incorporate therapeutic elements, improve the therapeutic alliance, help increase adolescent engagement in therapeutic activities between sessions with a therapist as well as in actual sessions, increase the amount of time clients give between sessions to working on their issues, increase client task completion rate, and reduce stigma attached to therapy through positive associations with gaming.
The proposed research aims to evaluate the potential of mobile therapeutic games to overcome difficulties faced by therapists in engaging adolescents in therapeutic activities between therapeutic sessions. It also aims to discover whether this approach might save therapist session time by bringing therapy outside of sessions and into adolescents' everyday life.

There have been studies of the potential educational uses of mobile games to facilitate cooperative learning and to examine their potential as tools for supporting learning. There has been little research into the therapeutic use of mobile technology. Some studies have examined the use of text messaging in client aftercare, while others have tentatively explored the use of mobile devices to structure client narratives. To date, there has been a lack of research exploring the effects mobile therapeutic games could have on adolescent engagement in therapy.

Contact:
Mark, Matthews
Trinity College Dublin
Ireland.
Ph: +353-1-6081765

Fax: +353-1-6772204
Email: matthemj@tcd.ie

Presenter: Elizabeth L. McGarvey EdD

INTERACTIVE COMPUTER IMAGINING TO FACILITATE COPING WITH CHEMOTHERAPY-RELATED ALOPECIA DISTRESS

Elizabeth L. McGarvey, EdD, Adrienne Keller, PhD, David Brenin, MD, Lora Baum, PhD, Brian Clark, Scott Acton, PhD, B. Eugene Parker, Jr, PhD

Univeristy of Virginia· Charlottesville, VA, USA

Background/Problem

As many as 47% to 58% of women with cancer report alopecia as the most disturbing anticipated aspect of receiving chemotherapy.[1] This project develops and evaluates the effectiveness of a computer imagining system that presents virtually real images of a woman going through the stages of hair loss/ regrowth as part of a strategy to provide psychosocial support to reduce distress associated with chemotherapy-related alopecia.

Methods

Following Phase I development of a prototype of a computer imaging system, further development of a user-friendly, touch screen, interaction system that shows hair re-growth and images sufficient for use to provide psychosocial support to women with cancer is now under development. The project has a number of tasks prior to the final evaluation of the system: Task 1: Following Phase 1 focus groups with a sample of patients provided feedback on the usefulness of such a system. Alopecia-related distress was also further studied. Task 2: A sample of health care professionals were interviewed to provide feedback on the accuracy of the images and usefulness of the system. Task 3: Complete and refine the computer imagining system. Task 4: Conduct a randomized clinical trial comparing quality of life between patients with chemotherapy-related alopecia who use the computer imaging system to those who receive standard care.

Results

Tasks 1 and 2 have been completed. The system is under Phase 2 development as part of Task 3. Themes associated with chemotherapy-related alopecia include *shock, embarrassment, feeling unprepared,* and *anxiety about self and others perceptions*. On a scale of 1 = not all easy to 10 = extremely easy to use, a non-clinical sample rated the prototype system no lower than a mean of 8.66 (SD=1.28) on ease of use in 4 areas. Health care professionals in oncology rated the realism of images on a similar scale with the lowest score received a mean of 8.94 (SD= .93). Phase II is currently underway with a 2006 completion date.

Conclusion

Interactive computer imaging systems using virtual images have a viable place in treatment for distress in cancer patients suffering quality of life issues due to alopecia.

References

1. McGarvey, E.L., Baum, L.D., Pinkerton, R.C., & Rogers, L.M. (2001). Psychological sequelae and intervention for treatment-induced alopecia among female cancer patients. *Cancer Practice, 9*(6), 283-289.

Contact:
Department of Psychiatric Medicine
University of Virginia
P.O. Box 800623
Charlottesville, VA 22908-0623
Tel: 434-924-5522
Fax: 434-982-3764
E-Mail: rel8s@virginia.edu

Presenter: Sarah D. Miyahira PhD

THE MATURING OF VIRTUAL REALITY RESEARCH IN BEHAVIORAL HEALTH: A META-ANALYSIS AND REVIEW

Sarah D. Miyahira, Ph. D.

Pacific Telehealth & Technology Hui: A DoD/VA Joint Venture

Research Status: In Progress

Background/Problem

Since the early 1990's, the research on virtual reality (VR) applications for behavioral health has progressed from exploratory case studies and feasibility studies to comparisons with wait-list and active treatment control groups. This maturation of the field has set the foundation for conducting meta-analytic and review studies of the research findings to date. The current investigation presents a comprehensive review of the published VR research in four clinical domains: (1) anxiety disorders, (2) eating disorders, (3) pain analgesia, and (4) addictions. In addition, a meta-analysis of andomized controlled studies of VR applications in behavioral health provides a summary of effect sizes, making it possible to draw stronger conclusions regarding the efficacy of VR interventions than significance testing results alone. As such, this study builds and expands upon recently published reviews of VR for anxiety disorders[1-3] and eating disorders.[4] The results of this investigation should be highly relevant and disseminable for researchers in the area of VR and the more general area of behavioral health.

Method

The investigation consists of a systematic review of the research to February 2005 as well as a meta-analysis of the literature. Utilizing PsychInfo and Medline, all of the published and abstracted studies in the four clinical domains described earlier were identified and reviewed. Each study was categorized as (1) a case study/uncontrolled study, (2) a wait-list/attention placebo controlled study, or (3) an active treatment/standard care controlled study. The meta-analysis combines the effect sizes from all controlled studies to produce general indicators of the efficacy of VR interventions for behavioral health.

Results

The review component of the investigation has been completed of VR studies related to behavioral health published through December 2004. Thus far, the data indicate that 73 outcome studies have been published across the four clinical domains with 19% (14) being wait-list or attention placebo studies, and 18% (13) active treatment or standard care controlled trials. A more detailed review of each clinical domain was done to assess the scope of the research conducted within the specific domain. Preliminary effect sizes computed for select studies were large in magnitude, and a meta-analysis will be performed with the identified controlled VR studies, including those published in early 2005.

Conclusions

The findings to date suggest that VR for behavioral health is a maturing field that holds considerable promise with continued research. Most of the published studies are either case studies or uncontrolled feasibility studies, particularly for novel uses of VR in behavioural health. Additionally, some clinical domains have had relatively minimal attention (e.g., addictions) as compared to others (e.g., anxiety disorders). Preliminary calculations of effect sizes indicate high efficacy of VR, which is not only encouraging for the field, but supports the need for more controlled studies across clinical domains. It is essential that there be a better balance between innovation and validation to establish VR as an effective intervention for behavioural health.

Novelty

To our knowledge, this is the first statistical meta-analysis of VR for behavioral health. In addition, this review includes studies and clinical domains that were not included in previous reviews.

References

1 Anderson, P., & Jacobs, C. (2004). Computer-supported cognitive behavioral treatment of anxiety disorders. Journal of Clinical Psychology, 60:253-267.
2 Krijn, M., Emmelkamp, P. M. G., Olafsson, R. P., & Biemond, R. (2004). Virtual reality exposure therapy of anxiety disorders: A review. Clinical Psychology Review, 24:259-281.
3 Wiederhold, B. K., & Wiederhold, M. D. (2005). Virtual Reality Therapy for Anxiety Disorders. Washington, DC: American Psychological Association.
4 Myers, T. C., Swan-Kremeier, L., Wonderlich, S., Lancaster, K., & Mitchell, J. E. (2003). The use of alternative delivery systems and new technologies in the treatment of patients with eating disorders. International Journal of Eating Disorders, 36:123.

Contact:

Sarah D. Miyahira
Pacific Telehealth & Technology Hui: A DoD/VA Joint Venture
1 Jarrett White Road
MCPA-PO, Tripler AMC
Honolulu, Hawaii 96859-5000
Phone: 1-808-433-1912
Fax: 1-808-433-1920
Email: sarah.miyahira@med.va.gov

Presenter: Andreas Mühlberger PhD

SUBJECTIVE AND PHYSIOLOGIC REACTIONS OF FLIGHT PHOBICS DURING VR EXPOSURE AND TREATMENT OUTCOME: WHAT ADDS MOTION SIMULATION?

Andreas Mühlberger, Ph.D., Georg Wiedemann and Paul Pauli

Department of Psychology, Biological Psychology, Clinical Psychology, and Psychotherapy, University of Würzburg, Würzburg, Germany

Background/Problem

The efficacy of virtual reality (VR) exposure for the treatment of fear of flying was confirmed in more than 8 controlled clinical trials. Important goals of future studies are the evaluation of underlying treatment processes and the identification of crucial treatment components, both in order to optimize the treatment. The present study was designed to examine the effect of motion simulation on subjective and physiological fear reactions as part of a VR exposure that also included visual and acoustic stimuli. Our hypotheses were that motion simulation results in stronger initial subjective and physiological fear reactions, and as a consequence is associated with stronger habituations of fear responses within VR flights and between VR flights. Furthermore, we assumed that motion simulation enhances treatment efficacy as measured in the fear of flying scale (FFS).

Methods and Tools

Twenty five participants with flight phobia received a virtual reality exposure treatment including written information about fear of flying and how to cope with it (information booklet), one hour of cognitive therapy, and VR exposure (four flights). However, VR exposure included for twelve participants motion simulation while thirteen participants received VR exposure *without* motion simulation.

Virtual flights consisted out of different flying phases (start, flying, turbulences, landing) and were simulated using a head mounted display (HMD), a head tracking device and a motion platform to simulate accelerations and provide proprioceptive stimuli.

Results

Overall, subjective fear ratings as well as skin conductance responses confirmed substantial fear of both groups during VR exposure. However, these responses were substantially stronger and habituated slower in the VR motion group compared to the VR no-motion group. Nevertheless and in contrast to network theories – which suggest that stronger activation of fear networks should result in an enhanced treatment outcome - we found no differences between groups in treatment outcome. There was no trend of a superior treatment outcome for the VR-motion compared to the VR-no-motion group.

Conclusions and Novelty

The present study helps to better understand VR exposure treatment and gives hints for future research to evaluate the treatment process. Based on our results it may be speculated that treatment outcome is more related to the amount of habituation during exposure than to the strength of the initial fear response.

Contact:
Andreas Mühlberger, Ph.D.
Department of Psychology
University of Würzburg
Marcusstr. 9-11
97070 Würzburg, Germany
Tel.: +49 (0)931-312843
Fax: +49 (0)931-312733
E-mail: muehlberger@psychologie.uni-wuerzburg.de

Presenter: Sarah Parsons PhD

USE, UNDERSTANDING AND LEARNING IN VIRTUAL ENVIRONMENTS BY ADOLESCENTS WITH AUTISTIC SPECTRUM DISORDERS

Sarah Parsons, Ph.D

School of Education, University of Birmingham

Background

The potential for using Virtual Environments (VEs) with children with autistic spectrum disorders (ASDs) has been recognised by some authors. The central premise is that interactions in VEs may be less threatening for children with ASDs compared to the 'real world' because many of the confusing inputs of real world interaction can be directly controlled and/or manipulated. The present research investigated whether single-user VEs could support the learning of social skills by adolescents with ASDs.

Method

A series of quasi-experimental studies was carried out to investigate three main research questions; would adolescents with ASDs be able to use the VEs appropriately, understand VEs as representational devices, and/or learn new information from VEs about social skills?

Single-user VEs were developed to show different social contexts, such as a bus and a café, and participants completed a number of tasks such as finding a place to sit, navigating to the counter to buy food/drink and queuing. Non-autistic comparison groups were included where possible and participants were also interviewed about their experiences and understanding. All sessions were videotaped for later analysis, such as time taken to complete the tasks, navigational paths, and verbal responses. Independent measures of verbal (VIQ) and non-verbal (PIQ) understanding, and Executive ability were also taken.

Results

In Study 1, participants with ASDs were not significantly different from a PIQ-match group in time taken to complete VE-based tasks, and the majority understood the VE as having basic representational qualities. Study 2 showed that a majority of participants with ASDs behaved in a similar way to non-autistic comparison groups by treating the VE like a game in most situations. A third of the ASD group (4 out of 12) showed substantial 'off-task' behaviour, which was linked to low VIQ and weak executive abilities. Study 3 looked at learning directly and found that participants improved in their awareness of social conventions, both in terms of performance in the virtual café and in judgments and comments made in relation to some video clips (which served as approximations of real life judgments). Study 4 involved case studies with two participants and showed that both appeared to learn the target social conventions and commented on how the VE could be relevant to their lives.

Conclusion

The overall findings suggest that some adolescents with ASDs can use, understand and learn social skills/conventions presented in VEs. The main challenge now is to reflect on these findings in order to shape future work. Specifically, there is a need to consider the role of the facilitator in 'scaffolding' participants' use of the VEs. To what extent can facilitation be separated from the effect of the VE itself? If the aim is to provide educational support, is a separation of factors desirable anyway?

Novelty

This series of studies represents a systematic and detailed addition to the scant existing literature on the use of VEs by children with ASDs. The investigation into representational understanding, inclusion of carefully matched comparison groups, and consideration of clearly specified social learning objectives are particularly noteworthy aspects of the research.

Contact:
Sarah Parsons Ph.D
School of Education
University of Birmingham Edgbaston
Birmingham UK B15 2TT
Phone: +44 (0) 121 414 4819
Fax: +44 (0) 121 414 4865
Email: s.j.parsons@bham.ac.uk

Presenter: Paul Penn PhD

VIRTUAL REALITY IN MEMORY ASSESSMENT AND REHABILITATION: PROGRESS TO DATE AND FUTURE POTENTIAL

Paul Penn. BSc (Hons), Ph.D., Barbara Brooks. BSc, Ph.D., David Rose. BSc, Ph.D. FBPsS

University of East London. UK

From its inception in 1994, the Virtual Reality Research Group at the University of East London recognised the enormous potential of virtual reality (VR) as a highly flexible, rigorously controllable, yet non-invasive method of directly assessing and manipulating brain activity in order to reduce the impact of brain damage. Studies have been conducted to address whether individuals who have suffered brain damage can use VR,[1] whether what is learned in VR transfers to the real world,[2] and the implications of active interaction vs. passive manipulation within virtual environments.[3] Experiments have encompassed individuals who have suffered brain damage as a result of vascular,[1] traumatic,[4] degenerative,[5] and developmental factors.[6]

Memory impairments are one of the most disabling consequences of brain injury.[7,8] They can be problematical to assess, as conventional "paper and pencil" neuropsychological tests of memory and cognitive function do not adequately cover important aspects of everyday memory, such as prospective memory (remembering to perform actions in the future) and incidental memory (the encoding and recall of memories without any instructions from a third party).[9] Paper and pencil tests have also been heavily criticized as lacking "ecological validity,"[10] Unfortunately, it can be very difficult to achieve ecological validity without compromising experimental control.

Virtual environments provide an elegant solution to the problem of developing memory tests and rehabilitation strategies that are valid from both empirical and ecological standpoints. In spite of this, it is probably fair to argue that research into memory assessment and rehabilitation in VR has been underexploited. However, some progress has been made; for example, researchers have developed VEs to: assess incidental and spatial memory via active interaction and passive observation[1,11]; enhance the restoration of memory function in individuals with dementia[12]; facilitate in the reorganisation of memory skills to use unimpaired functions in order to train patients with amnesia to navigate around a rehabilitation ward[13,14]; encourage the development of spatial memory in children whose physical disabilities restrict their mobility[15,16,17]; and motivate patients with traumatic brain injury (TBI) to participate in exercise in order to stimulate memory remediation.[18] There has also been some preliminary research on prospective memory in patients who have suffered a stroke[19] and older individuals.[20] Finally, using VR together with fMRI offers exciting opportunities to address the neurophysiological basis of different types of memory.[21] These, and other possibilities, are discussed.

This paper evaluates the current state of research on the applications of VR to memory assessment and rehabilitation, proposes some directions for future research, describes some recent work on VR and prospective memory being conducted at UEL, and suggests a strategy for turning our research findings into real benefits for patients.

References

Rose, F. D., Brooks, B. M., Attree, E. A., Parslow, D. M., Leadbetter, A. G., McNeil, J. E., Jayawardena, S., Greenwood, R., & Potter, J. (1999). A preliminary investigation into the use of virtual environments in memory retraining of patients with vascular brain injury: Indications for future strategy? Disability and Rehabilitation, 21; 548-554.

Rose, F. D., Attree, E. A., Brooks, B. M., Parslow, D. M., Penn, P. R., & Ambihaipahan, N (2000). Training in virtual environments: Transfer to real world tasks and equivalence to real task training. Ergonomics; 43, 494-511.

Andrews, T. K., Rose, F. D., Leadbetter, A. G., Attree, E. A., & Painter, J. (1995). The use of virtual reality in the assessment of cognitive ability. In I. Placencia Porrero and R. Puig de la Bellacasa (Eds.), Proceedings of the 2nd TIDE Congress; 276-279. Amsterdam: IOS Press.

Brooks, B. M., Attree, E. A., Rose, F. D., Clifford, B. R, & Leadbetter, A. G. (1999). The specificity of memory enhancement during interaction with a virtual environment. Memory, 7(1); 65-78.

Andrews, T. K. (1999). Virtual environments and memory training: A preliminary investigation into the feasibility and efficacy of training amnesic patients in a virtual environment. Unpublished doctoral dissertation, University of East London.

Rose, F. D., Brooks, B. M., & Attree, E. A. (2000). Virtual reality in vocational training

of people with learning disabilities. *Proceedings of the International Conference on Disability, Virtual Reality and Associated Technologies-ICDVRAT2000*; 129-136. Reading, UK: University of Reading.

Kinsella, G., Murtagh, D., Landry, A., Jomfray, K., Hammond, M., Obeirn, L., Dwyer, L., Lamont, M., and Ponsford, J. (1996) Everyday memory following traumatic brain injury, *Brain Injury* 10; 499-507.

Thone, A.I.T. Memory rehabilitation - Recent developments and future directions (1996) *Restorative Neurology and Neuroscience 9*; 125-140.

Brooks, B. M., Rose, F. D. (2003) The use of virtual reality in memory rehabilitation: Current findings and future directions. *NeuroRehabilitation*, Vol 18(2); 147-157.

Neisser, U. Memory: What are the important questions? in: *Practical Aspects of Memory*, M.M. Gruneberg, P.E. Morris and R.N. Sykes, eds., Academic Press, London, 1978; 3-24.

Brooks, B.M., Attree, E.A., Rose, F.D., Clifford, B.R., & Leadbetter, A.G. (1999). The specificity of memory enhancement during interaction with a virtual environment, *Memory* 7; 65-78.

Schreiber, M., Schweizer, A., Lutz, K., Kalveram, K.T., and Jäncke, L. Potential of an interactive computer-based training in the rehabilitation of dementia: An initial study, *Neuropsychological Rehabilitation* **9** (1999), 155-167

Brooks, B. M., McNeil, J. E., Rose, F. D., Greenwood, R. J., Attree, E. A., & Leadbetter, A. G. (1999). Route learning in a case of amnesia: The efficacy of training in a virtual environment. *Neuropsychological Rehabilitation*, 9(1); 63-76.

Rose, F.D., Attree, E.A., Brooks, B.M., and Andrews, T.K. Learning and memory in virtual environments: A role in neurorehabilitation? Questions (and occasional answers) from the University of East London, *Presence* 10 (2001), 345-358.

Stanton, D., Foreman, N., and Wilson, P. Uses of virtual reality in training: developing the spatial skills of children with mobility impairments, in: *Virtual Environments in Clinical Psychology and Neuroscience: Methods and Techniques in Advanced Patient Interaction*, G. Riva, B.K. Wiederhold and E. Molinari, eds. IOS Press, Amsterdam, 1998, pp. 219-232.

Stanton, D., Foreman, N., Wilson, P., Duffy, H., and Parnell, R. Use of virtual environments to acquire spatial understanding of real-world multi-level environments, *Proceedings of the 4th International Conference on Disability, Virtual Reality and Associated technologies, Hungary*, 2002, pp. 13-18.

Stanton, D., Wilson, P., Foreman, N., and Duffy, H. Virtual environments as spatial training aids for children and adults with physical disabilities, *Proceedings of the 3rd International Conference on Disability, Virtual Reality and Associated technologies, Sardinia*, 2000, pp. 123-128.

Grealy, M.A., Johnson, D.A., and Rushton, S.K. Improving cognitive function after brain injury: The use of exercise and virtual reality, *Archives of Physical Medicine and Rehabilitation* **80**, 1999, 661-667.

Brooks, B.M., Rose, F.D., Potter, J., Attree, E.A., Jayawardena, S. & Morling, A. (2002) Assessing stroke patients' ability to remember to perform actions in the future using virtual reality, *Proceedings of the 4th International Conference on Disability, Virtual Reality and Associated Technologies, Hungary*, 2002; 239-245.

Brooks, B.M., Rose, F.D. (2003) The effects of age and cognitive load on time-based, event-based, and activity-based prospective memory task retrieval in a virtual environment. Unpublished data.

Morris, R.G., Parslow, D. Fleminger, S., Brooks, B., Brammer, M., and Rose, D. (2002) Functional magnetic resonance imagining investigation of allocentric spatial memory tested using virtual reality in patients with anoxic hippocampal damage, *Proceedings of the 4th International Conference on Disability, Virtual Reality and Associated Technologies, Hungary*, pp. 87-92

Contact:
Paul Penn Ph.D
School of Psychology.
University of East London. UK.
Telephone: +44(0) 208 223 [4424|4425|4500]
E-mail: P.R.Penn@uel.ac.uk

Presenter: Thomas Penzel PhD

NEW SENSOR DEVELOPMENT FOR THE DETECTION OF SLEEPINESS IN THE WORK AND TRAFFIC ENVIRONMENT AND SLEEP LABORATORIES

T. Penzel[1], H.F. Becker[1], I. Lekka[2], E. Bekiaris[3]

[1] Hospital of Philipps-University, Dept. of Internal

Medicine, Pneumology, Marburg, Germany
[2] Aristoteles University of Thessaloniki, Greece
[3] Centre for Research and Technology Hellas, Hellenic Inst. of Transportation, Thessaloniki, Greece

Research status: In Progress

Background

Sleepiness in the work and traffic environment can cause severe accidents. Sleepiness is either the consequence of sleep loss or sleep deprivation or of a sleep disorder. Car accidents have more fatal outcomes at night than during the day. Drowsy or sleepy drivers and workers at monitoring tasks do have a slower response to react adequately to alarms or dangerous situations. Therefore there is a need to monitor sleepiness in such circumstances.

Methods: A European project uses existing technologies and sensors to develop new integrated systems in order to detect a lower vigilance at an early stage. Definitions for the different levels of sleepiness were developed based on monitoring of brain function[1] and autonomous nervous system functions.[2] The most sensitive parameters will be chosen in order to monitor sleepiness without impairment of the driver or worker. An alarm or other adequate feedback will be developed in order to create awareness to the driver or worker. The same sensors are also used for the medical applications in order to diagnose sleep disorders. The specific challenge is to detect sleep disorders at an early stage in order to initiate prevention programs.

Results

A set of important signals for the identification of sleepiness has been identified. The electroencephalogram, the electromyogram, and heart rate are sensitive signals. Among all sleep disorders the most prevalent sleep disorders are addressed. These are insomnia, sleep disordered breathing, periodic limb movements during sleep, and narcolepsy. Application scenarios for work environment as well as for diagnostic and treatment approaches were defined.

Conclusions

The definitions reached up to now allow to specify systems for use in the work and traffic field as well as in the medical environment. The new developed sensors and analysis algorithms are then applied in sleep laboratories and intensive care medicine with monitoring demands. Wireless data transmission based on body area network technologies is of major importance for these applications.

Novelty

Existing applications in sleep diagnosis are based on wired technology and are restricted to hospital based sleep laboratories. The new systems will allow a medical diagnosis in outpatient settings with the same signal quality as reached in the hospital until now. The systematic approach to signals and parameters will enable the development of improved algorithms for diagnosis. Sensors technology developed for automotive purposes can be reused in medical diagnostic environment.

References

1. A. Rechtschaffen and A. Kales, A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects. NIH Publication No. 204. Washington D.C.: U.S. Government Printing Office 1968.
2. T. Penzel and R. Conrad, Computer based Sleep Analysis, Sleep Medicine Reviews 2000; 4: 131-148.

Contact:
Thomas Penzel
Hospital of Philipps-University
Depart. of Internal Medicine
Marburg, D-35033
Germany
Phone: +49-6421-2866435
Fax: +49-6421-2865450
Email: penzel@med.uni-marburg.de

Presenter: Alessandra Preziosa

MOBILE NARRATIVES TO IMPROVE THE QUALITY OF LIFE: AN EXPERIMENTAL RESEARCH

Preziosa, A., A. Grassi, D. Villani, F. Mantovani, Ph.D, J. Waterworth Ph.D, J. Freeman Ph.D, G. Riva

Applied Technology for Neuro-Psychology Lab
Istituto Auxologico Italiano

Abstract

The market of mobile phones is increasing quickly and now account for shipments of over 400 million units per year. The mobiles of new generation bring much functionality, as PDA, cameras, gaming devices, or media players. These innovations will grow in the next years, so a new generation of hardware-accelerated mobile devices will soon be joined by a suite of emerging 3D software standards that gives developers the ability to create interactive content and applications that haven't been possible before.

In this context, mobile narratives are emerging as possible applications. Mobile narratives are interactive multimedia experiences implemented on mobile devices, in which the narrative component is a critical aspect to create a feeling of presence and engagement.

The mobile narratives, through the link between the feeling of presence and the emotional state, may be used to improve the mood state in the users. In particular, mobile narratives may be used for both modifying the user's mood and helping him to relax, enhancing his well-being.

Relaxing is a difficult activity, especially in everyday life. Many of us are usually involved in stressful situations far away from the context required by the classical relaxation techniques. In this study - supported by the Italian "NeuroTiv" MIUR FIRB research project[1] we developed a mobile narrative for UMTS phones to be used by commuters to improve their well-being. The narrative, based on a trip in a desert tropical island, relaxes the user through different audio-visual experiences. They include the exploration of the island and different relaxation techniques based on the Progressive Relaxation protocol developed by Jacobson.[2]

The experimental sample is composed by 90 commuting students, aged between 20 an 24, randomly divided in 3 different conditions: the experimental group, which experienced the mobile narrative during their daily train trip; a first control group, which experienced a relaxing new age DVD during their train trip; and a second control group, which experienced the train trip only.

Each subject was submitted before and after the experience to the following questionnaires the PANAS (*Positive and Negative Affects Schedule*)[3] and the STAI (*State Trait Anxiety Inventory*).[4]

The final results will be presented at the Cybertherapy 2005 conference.

References

http://www.neurotiv.org/

Jacobson, E. (1938) *Progressive Relaxation.* Chicago. U. of Chicago Press.

Watson, D.; Clark, L.A.; Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality & Social Psychology, 54(6).*

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983) Manual for the State-Trait Anxiety Inventory (Form Y). Palo Alto, CA: Mind Garden.

Contact:
Alessandra Preziosa
Applied Technology for Neuro-Psychology Lab
Istituto Auxologico Italiano
Via Pelizza da Volpedo 41
Milan, Italy
Ph./Fax +39-02-619112892
Email: a.preziosa@auxologico.it

Presenter: Patrice Renaud PhD

THE RECORDING OF GAZING RESPONSES IN VIRTUAL IMMERSION: A NEW CLINICAL TOOL TO ASSESS SEXUAL PREFERENCES IN PARAPHILIAS

Patrice Renaud, Ph.D.[1], Jean Proulx, Ph.D.[2], Joanne L. Rouleau, Ph.D.[2], Stéphane Bouchard, Ph.D.[1], Gina Madrigrano, Ph.D.[3], John Bradford, M.D.[3], Paul Fedoroff, M.D.[3]

[1] Département de psychoéducation et de psychologie, Université du Québec en Outaouais
[2] Université de Montréal
[3] Forensic Program, Royal Ottawa Hospital

Research status: In progress

Sexual preferences are usually assessed either by resorting on sexual responses recorded with a penile plethysmograph or by using visual reaction time from stimuli with

sexual content. However, numerous shortcomings come with penile plethysmography and visual reaction time, and notably voluntary erectile control and not paying attention to stimuli, which are important threats to the internal validity of these assessment procedures. In order to get round these limitations, we developed a method that controls gazing activity relative to sexual avatars. A study is conducted using our method that is aiming at assessing sexual preferences with sex offenders and control subjects interacting with sexual avatars.

Background

Sexual preferences are usually assessed either by resorting on sexual responses recorded with a penile plethysmograph or by using visual reaction time from stimuli with sexual content. However, numerous shortcomings come with penile plethysmography and visual reaction time, and notably voluntary erectile control and not paying attention to stimuli, which are important threats to the internal validity of these assessment procedures. In order to get round these limitations, we developed a method that controls gazing activity relative to sexual avatars. A study is conducted using our method that is aiming at assessing sexual preferences with sex offenders and control subjects interacting with sexual avatars.

Methods

Our method relies upon a technological setting including what is usually necessary to present virtual environments in immersion plus equipments dedicated to eye-movements tracking from within a head mounted display (HMD). A special mounting built from a monocular infrared eye-tracking system combined within a binocular HMD is used to track eye-movements. Head-movements are recorded from a magnetic tracking system rendering the 6 degrees-of-freedom (DOF) of translation and rotation. Our method performs gaze analysis by the way of virtual measurement points (VMP) placed on virtual objects for the analysis of eye-movements in relation to specific features of these objects. Gaze radial angular deviation (GRAD) from the VMP is given by the combinations of the 6 DOF developed by head-movements and the x and y coordinates rendered by the eye-tracking system. The VMP is locked to virtual objects and moves jointly with them. While the variations in the 6 DOF developed by head-movements define changes in the global scene presented in the HMD, the 2 DOF given by the eye-tracking device allow the computation of the exact position of the line of sight relative to the VMP. As other physiologic signals, we also measure the subject's distance from the VPR, the pupil size diameter, the blinking response and the erectile response recorded with a penile plethysmograph. The 3D stimuli that we used are animated naked human models.

Results

Preliminary results from sex offenders and control subjects will be presented. These results will consist in analyses performed on time series coming from oculomotor and other physiologic responses recorded in immersion.

Novelty

The novelty of this method for assessing sexual preferences was acknowledged at the last Conference of the Association for the Treatment of Sexual Abusers held October 2004 in Albuquerque (NM). These results inscribe themselves in the extension of our past studies whose goal was mainly to make sense of the perceptual and motor dimensions of virtual immersion.[1-5] They also pave the way to interactive behavior and perception modification therapies based on eye-tracking recorded in VR.[6,7]

References

1. Renaud, P., Singer, G., & Proulx, R. (2001). Head-tracking fractal dynamics in visually pursuing virtual objects. In Sulis W., Trofimova I. (Eds.), *Nonlinear Dynamics in Life and Social Sciences* (NATO Science series, Vol. 320), Institute of Science Press (IOS Press), Amsterdam, pp 333-346.
2. Renaud, P., Cusson, J.-F., Bernier, S., Décarie, J., Gourd, S.-P., & Bouchard, S. (2002). Extracting perceptual and motor invariants using eye-tracking technologies in virtual immersions. Proceedings of *HAVE'2002-IEEE (Institute of Electrical and Electronics Engineers) International Workshop on Haptic Virtual Environments and their Applications,* Ottawa, pp. 73-78.
3. Renaud, P., Rouleau, J.-L., Granger, L., Barsetti, I., & Bouchard, S. (2002 c). Measuring sexual preferences in virtual reality: A pilot sudy. *Cyberpsychology and*

Behavior, 5 (1), 1-10.
4. Renaud, P., Bouchard, S., & Proulx, R. (2002). Behavioral avoidance dynamics in the presence of a virtual spider. *IEEE (Institute of Electrical and Electronics Engineers). Transactions in Information Technology and Biomedecine, 6 (3)*, 235-243.
5. Renaud, P., Décarie, J., Gourd, S.-P., Paquin, L.-C., & Bouchard, S. (2003). Eye-tracking in immersive environments : a general methodology to analyze affordance-based interactions from oculomotor dynamics. *Cyberpsychology and Behavior, 6 (5)*, 519-526.
6. Renaud, P. (2004). Moving assessment of sexual interest into the 21st century : the potential of new information technology. Invited speaker at *The 23rd Annual Research and Treatment Conference (Association for the Treatment of Sexual Abusers)*, Albuquerque, 27-30 October 2004.
7. Renaud, P., Albert, G., Sauvé, L., Renaud, L., Décarie, J., & Bouchard, S. (2004). Assessing perceptual learning dynamics during visual search in virtual immersion using eye-tracking technologies. Cognition and Learning in Digital Age (CELDA 2004), Lisbon, 15-17 December, 6 pages.

Contact:
Patrice Renaud, Ph.D.
Laboratoire de cyberpsychologie
Université du Québec en Outaouais
Institut Philippe-Pinel de Montréal
C.P. 1250, Succ. B
Gatineau (Québec) Canada, J8X 3X7
Tel. : 819 595 3900
Email: patrice.renaud@uqo.ca,

Presenter: Giuseppe Riva PhD

VIRTUAL REALITY IN EATING DISORDERS AND OBESITY: STATE OF THE ART AND FUTURE DIRECTIONS

Prof. Giuseppe Riva, Ph.D.

Applied Technology for Neuro-Psychology Lab
Istituto Auxologico Italiano

The first study describing the possible use of virtual reality in the treatment of eating disorders and obesity was published in 1995. Since then, different researchers have been studying the possible advantages of virtual reality as experiential technique able to modify the body image, self-efficacy and emotional control of the patient.

This presentation will review the state of the art in this research field. In particular, it will discuss the result coming from different controlled trials comparing this approach with competing techniques.

Further, the presentation will address the future directions of this method focusing on the possible opportunities coming from Internet and mobile devices.

Presenter: Albert "Skip" Rizzo PhD

GAMES FOR HEALTH: GAME-BASED VIRTUAL REALITY APPLICATIONS FOR MENTAL DISORDERS & REHABILITATION

Albert "Skip" Rizzo[1], Jarrell Pair, Galen Buckwalter, Jeff Gold, Carolee Winstein, Margaret McLaughlin, Ken Graap, Brenda Wiederhold

[1] University of Southern California Institute for Creative Technologies

The rapidly growing popularity of digital gaming has driven advances in game-based technology that has now added new momentum to the vision of creating immersive and interactive experiential opportunities for a wide range of human needs beyond just the entertainment value that come from playing games. In addition to the readily intuitive application of game-based earning for education and training purposes (Prensky, 2001), the mental health and rehabilitation fields stand to substantially benefit from advances in this area. The integration of game technology and experiences with VR-based approaches for clinical assessment, treatment, and rehabilitation offers powerful options that could revolutionize standard practices in these fields. Thus far, the integration of gaming features into a VE has been reported to enhance motivation in adult clients undergoing physical and occupational therapy following a stroke (Jack et al, 2001; Kizony, Katz & Weiss, 2003) and to reduce acute pain during medical procedures (Hoffman et al., 2000). As well, Strickland (2001) reports that children with autism were observed to become very engaged in the VR safety training applications that she has developed which incorporate game features. Further anecdotal observations suggest that children diagnosed with Attention Deficit Hyperactivity Disorder

often have a fascination for the type of stimulus environments that are presented in computer/video games (Greenhill, 1998). Parents are often puzzled when they observe their children focusing on computer games intently, while teacher reports indicate inattention in the classroom. Additionally, in the presenter's previous clinical experience, it was anecdotally observed that certain young adult traumatic brain injury clients, who had difficulty maintaining concentration on traditional cognitive rehabilitation tasks, would easily spend hours at a time playing the computer game "SimCity." These observations suggest that designers of clinical assessment and treatment tasks could benefit from examining the formulas that commercial game developers use in the creation of interactive digital games. These formulas govern the flow and variation in stimulus pacing that provide linkage to a progressive reward and goal structure. When delivered within a highly interactive graphics-rich environment, users are commonly observed to become extremely engaged in this sort of game play. This presentation will describe a variety of ongoing projects at USC that integrate game technology with VR-based applications for the assessment, treatment and rehabilitation of cognitive, psychological, emotional, and physical disorders. These projects have focused on the development of applications for:

1. Attention process assessment in children with ADHD
2. Pain distraction in children undergoing painful medical procedures and chemotherapy
3. Exposure therapy in returning Iraq War veterans with PTSD
4. Motor rehabilitation for persons with central nervous system dysfunction (i.e. stroke, brain injury)

These applications have leveraged the assets that have come from advances in both game engine technology and from the unique experience that is fostered from the psychologically involving act of game play. Such USC initiatives may provide hope that innovative methods can be created to advance these areas that have long been mired in the methods of the past. My presentation will begin with an introduction on how and why game assets can be used to create applications in mental health and rehabilitation and then will review the data/status of our various projects.

Contact:
Albert "Skip" Rizzo
University of Southern California
Institute for Creative Technologies
13274 Fiji Way
Marina del Rey, CA, 90292
Phone: 213-610-4737
Email: arizzo@usc.edu

Presenter: Albert "Skip" Rizzo PhD

FROM TRAINING TO TOY TO TREATMENT: PRELIMINARY RESULTS FROM A VR THERAPY APPLICATION FOR IRAQ WAR MILITARY PERSONNEL WITH COMBAT-RELATED PTSD

Albert "Skip" Rizzo[1], Jarrell Pair, Peter J. McNerney, Ernie Eastlund, Brian Manson, Jon Gratch, Randy Hill, Michael Roy*, Bill Swartout, Ken Graap & Brenda Wiederhold

[1] University of Southern California Institute for Creative Technologies

In 1997, researchers at Georgia Tech released the first version of the Virtual Vietnam VR scenario for use as a graduated exposure therapy treatment for PTSD in Vietnam veterans. This occurred over 20 years following the end of the Vietnam War. During that interval, in spite of valiant efforts to develop and apply traditional psychotherapeutic approaches to PTSD, the progression of the disorder in some veterans severely impaired their functional abilities and quality of life, as well as that of their family members and friends. Prior to the availability of VR therapy applications, the existing standard of care for PTSD was imaginal exposure therapy. Such treatment typically involves the graded and repeated imaginal reliving of the traumatic event within the therapeutic setting. This approach is believed to provide a low-threat context where the patient can begin to therapeutically process the emotions that are relevant to the traumatic event as well as de-condition the learning cycle of the disorder via a habituation/ extinction process. While the efficacy of imaginal exposure has been established in multiple studies with diverse trauma populations (Rothbaum & Schwartz, 2002), many patients are unwilling or unable to effectively visualize the traumatic event. With this history in mind, the USC Institute for Creative Technologies (ICT) has initiated a project

that is creating an immersive virtual environment system for the treatment of Iraq War military personnel diagnosed with combat-related PTSD. The treatment environment is based on a creative approach to recycling virtual assets that were initially built for a combat tactical simulation scenario entitled Full Spectrum Command, and later licensed to create the commercially available X-Box game, Full Spectrum Warrior.

Thus far we have created a prototype virtual environment designed to resemble a Middle Eastern city. We intend to use this VE for initial clinical and patient user testing to gather feedback to refine the city scenario and for the future expansion of the system to include other relevant scenarios (e.g. outlying village and desert scenes, etc.) and user perspectives. We have also created an initial version of a "wizard of oz" type clinical interface. This interface is a key element in that it will provide a clinician with the capacity to customize the therapy experience to the individual needs of the patient by placing them in VE locations that resemble the setting in which the traumatic events initially occurred. The interface will also allow the therapist to gradually introduce and control "trigger" stimuli in the environment in real time as is required to foster the anxiety modulation needed for therapeutic habituation. This presentation will discuss the vision, rationale and user-centered development status of the Full Spectrum PTSD treatment system that is currently in progress at the ICT. As well, initial results will be presented from ongoing user-centered design trials that are part of the development of this immersive VR application for this highly relevant mental healthcare problem.

Contact:
Albert "Skip" Rizzo
University of Southern California
Institute for Creative Technologies
13274 Fiji Way
Marina del Rey, CA, 90292
Phone: 213-610-4737

Presenter: Geneviève Robillard MSc

COMPARATIVE STUDY OF IMMERSION TECHNOLOGY FOR A VIRTUAL BICYCLE

Geneviève Robillard, M.Sc.[1], Stéphane Bouchard, Ph.D., & Judith Lapierre, Ph.D.

[1] University of Quebec in Outaouais

Background

Virtual reality (VR) can become a useful tool to overcome obesity, especially for youngsters, considering its similarity to video games. This comparative study aim to assess what type of immersive display is preferred by youngsters for using a virtual bicycle. This is the first step in the development of a program to enhance motivation in obese youngsters to exercise.

Method/Tools

Twenty-one healthy participants aged 10-18 years old (mean age = 12.5, 52.4% male) were immersed three times (three minutes each) in a virtual environment using a different type of technology for each immersion (HMD, projector, television). The order of immersive technology was randomly assigned. The hardware used was a 10-speed bicycle connected to an I-Magic® VR trainer steering with an integrated tracker connected to a Pentium III® 866 Mhz PC. The HMDs used were an I-Visor® for half of the participants and an I-Glass®. An Eiki® LCD multimedia projector and a Sony® 27-inch television were used. Pre-post measures of Immersive Tendencies and the Simulator Sickness were completed. Subjective measures were administered after each immersion for presence, cybersickness, and preferences.

Results

Participant significantly preferred the HMD over the projector and the television. They felt more "present" using the HMD but also more cybersickness. No significant difference was found in the preference for the television vs. projector. Immersive Tendencies correlates significantly with presence when HMD was used.

Conclusion

Results indicate that levels presence, preference, and cybersickness are higher when using a HMD. Considering the purpose of this study, cybersickness has to be acknowledge since obese youngsters will use the virtual bicycle for a longer periods. The projector and television still had a high level of interest for participants and low cybersick-

ness. LCD projectors are the best technology to use as an immersive display for virtual exercises.

Contact:
Geneviève Robillard, M.Sc.
University of Quebec in Outaouais
Cyberpsychology Lab
Gatineau, Quebec J8X 2B7
Canada
Phone: (819) 776-8045
Fax: (819) 776-8098
Email: genevieve_robillard@ssss.gouv.qc.ca

Presenter: Ricardo Ron-Angevin

DEVELOPMENT OF A BRAIN-COMPUTER INTERFACE (BCI) BASED ON VIRTUAL REALITY TO IMPROVE TRAINING TECHNIQUES

Ricardo Ron-Angevin, PhD candidate, Antonio Díaz-Estrella, Arcadio Reyes-Lecuona

Departamento de Tecnología Electrónica, Universidad de Málaga

Research Status: In progress.

Background/Problem

A brain-computer interface (BCI) is based on the analysis of the electroencephalographic signals (EEG), recorded during certain mental activities, to control an external device. One of its main uses could be in the field of medicine and especially in rehabilitation. It could help to establish a communication and control channel for people with serious motor function problems but without brain function disorder.

Performance of BCI will depend, especially, on the ability of subjects to control their EEG patterns being necessary to provide suitable training. The vast majority of research in the BCI field puts emphasis on the importance of developing training methods based on biofeedback techniques that would improve human performance.

Training in BCI consists on carrying out some trials, repeated times, being very important to provide some type of feedback allowing subjects to see their progress [1]. Training protocols must not be chosen at random. On the contrary, in many cases, they must adapt to the subject to be effective. To design a suitable training protocol, it would be interesting to study possible effects that diferent type of feedback can have on subjects. Feedback may help subjects to improve their EEG control, but sometimes its effects can be frustrating. Besides,
conventional systems of feedback, such as cursor control or horizontal bar extension can prove somewhat boring, leading to a lack of motivation.

Method/Tools

To avoid this problem, feedback must be attractive, motivating subjects to control their EEG signals. For this, a good option is the use of techniques based on virtual reality [2], combining 3D display, sound and isolation. Using these techniques, a more natural interaction can be achieved, isolating subjects from distraction, and providing a more immersed and motivating environment. Based on virtual reality techniques, a new type of BCI system to enable to establish the appropriate feedback allowing subjects to get better control of EEG signals, is developed.

Results

This BCI allows to set parameters related to training paradigm timing (- duration, repetitiveness and pause between trials, - duration of the feedback period, - duration of the session), the type of feedback (continuous or discrete feedback) and the presentation of feedback selecting different scenes. Due to trial repetitiveness, interface were designed to be as appealing and motivating as possible. It was decided to submit subjects to a more familiar environment, such as controlling a car to avoid crashing it into a wall, to avoid logs in the road, or to reach a ramp that would make the car jump. Preliminary results show how this new system can be useful to study and to improve training protocol in BCI.

Conclusions

The new BCI system is very promising, providing an attractive training to the subject and allowing to adapt training protocols to be effective.

Novelty/Discussion

One of the differences of this new system, compared to conventional feedbacks, such as cursor control or horizontal bar extension, is the use of virtual reality to provide feedback with more immersive and motivating effects.

References

[1] Guger, C., Edlinguer, G., Harkam, W., Niedermayer, I.,
Pfurtscheller, G., 2003. How many people are able to operate an
EEG-Based Brain-Computer Interface (BCI). IEEE Trans. On Neural Systems
and Rehabil. Eng. 11, 145-147.
[2] J.A Pineda, D.S. Silverman, A. Vankov, and J. Hestenes, "Learning to
Control Brain Rhythms: Making a Brain-Computer Interface Possible," IEEE
Trans. Neural Systems and Rehab. Eng., vol. 11, pp.181-184, June 2003.

Contact:
Ricardo Ron-Angevin
Departamento de Tecnología Electrónica
Universidad de Málaga
Campus de Teatinos s/n 29071
Málaga, Spain
Phone: +34-952132897
Fax: +34-952131447
Email: rra@dte.uma.es

Presenter: Michael J. Roy MD MPH

USE OF STANDARDIZED PATIENTS AND COMPUTER-BASED SIMULATION FOR PHYSICIAN EDUCATION ON BIOTERRORISM

Michael J. Roy, MD, MPH

Uniformed Services University, Bethesda, MD

Continuing medical education has historically been provided largely through didactic classroom-style teaching. However, educators have identified this as one of the least effective methods of adult education. Adult learners are far more likely to retain new information that is required through experiential or self-directed learning. In addition, many young adults today havecome of age with significant experience with computer-based or "video" games. Comfort with new technologies renders new physicians and physicians-in-training ripe for medical education that engages them through such technologies. Similarly, it provides an opportunity to enhance treatment of their patients through such modalities.

We report our experience with the use of standardized patients (SPs) in educating physicians regarding the diagnosis and treatment of biological and chemical warfare agent exposure. We trained professional actors to serve as SPs representing exposure to the biological agents anthrax, smallpox, botulinum toxin, and staphylococcus enterotoxin B (SEB). We conducted workshops at two national medical meetings, with workshop participants rotating in small groups through a series of teaching stations where they were able to perform a medical history and physical examination, order tests, make a diagnosis, and establish a management plan. Workshop staff physicians then conducted discussions and emphasized key teaching points. In addition, we trained SPs to simulate a mass casualty (MASCAL) incident involving a terrorist spraying a liquid on a city bus, once using sarin, and in another case using hydrochloric acid. All workshop participants worked together to treat MASCAL victims, followed by debriefing and discussion.

We also describe a current project to develop computer-based interactive modules of simulated patients exposed to smallpox, anthrax, and other biological and chemical agents. The nature of the program allows the user to go through the simulation repeatedly, with a different presentation each time, based partly on the questions they pose and the way they ask them, as well as by chance. The program provides feedback on each question and on the overall conduct of the interview.

The advantages and disadvantages of each of these methods will be discussed.

Contact:
Michael J. Roy, MD, MPH
Professor of Medicine
Uniformed Services University
Bethesda, MD
USA

Presenter: Jaime Sánchez PhD

TRAINING BLIND CHILDREN TO DEVELOP MATHEMATICS SKILLS THROUGH AUDIO

Jaime Sánchez, Ph D.

University of Chile

It is well known that mathematics allow us to abstract and understand our surrounding world. Thus an early training to people in mathematics can help to develop better learning skills. People with visual disabilities can not learn mathematics easily. Mathematics is developed, represented, and communicated basically through visual means such as in algebraic expressions, graphs, and geometric figures. A few studies have approached this issue by studying new interfaces for mathematics learning.[1-4]

This research analyses how audio-based technology can be used as a powerful tool to train blind children to learn mathematics concepts. We introduce and analyze three audio-based software products to develop mathematics skills.

AudioMath is an audio-based interactive application that mimics the social board game Memory.[5,6] The child has to open pairs of tokens in a board with several levels of difficulty to find the corresponding pair of tokens in accordance with the mathematical content such as correspondence and equivalency relationships, memory development, and differentiating tempo-spatial notions.

Theo & Seth is an audio-based interactive virtual environment to enhance learning of number and basic operations with different levels of complexity. The metaphor used resembles a grange with two major virtual environments: the kitchen and the henhouse. The kitchen covers cardinality including the number, the position in the numerical straight line, information about the antecessor and successor; and the introduction of ordinal numbers. The henhouse is a virtual space where learners learn how to do sum and rest.

AudioGeometry is based on Van Hiele´s model of geometric thinking and serve as a guide for instruction and evaluation of geometric skills. The software is implemented with a useful scheme to organize content (plane figures, area, and perimeter). AudioGeometry consists of identifying, recognizing, and naming polygons and related elements as well as measuring geometric figures and calculating areas and perimeters of plane geometric figures.

We have tested these audio-based products with twenty blind learners from 7 to 15 years old in a school setting by using tests for mathematics knowledge and thinking, and audio memory. We implemented a case study by doing cognitive introspection during and after each task. Children were exposed to software with formal activities and solved related cognitive tasks during six months. We have preliminary evidenced that the use of audio-based software with related cognitive tasks can help to develop mathematics thinking and knowledge. Blind children have shown positive gains in learning addition, subtraction, multiplication, and division after interaction with audio-based virtual environments. They have improved the development and use of mathematics skills.

A usability evaluation was also implemented during and after the implementation. Children enriched the software after evaluating different modules during implementation and helping us to map their mental models.

Finally, this study adds preliminary knowledge to the field of learning of mathematics in blind children. We are beginning to understand how audio-based interfaces can help to develop mathematics knowledge and skills in blind learners.

References

Edwards, A. D. N. and Stevens, R. D. Mathematical representations: Graphs, curves and formulas. In D. Burger and J.-C. Sperandio (ed.) *Non-Visual Human-Computer Interactions: Prospects for the visually handicapped.* Paris: John Libbey Eurotext, (1993), pp. 181-194.

Sahyun, S., Gardner, S., & Gardner, C., Audio and Haptic Access to Math and Science - Audio graphs, Triangle, the MathPlus Toolbox, and the Tiger printer. *Proceedings of the 15th IFIP World Computer Congress*, Vienna, September 1998, pp. 78-86.

Karshmer A., Pontelli E., & Gupta, G., Helping Visually Impaired Students in the Study of Mathematics. *29th ASEE/IEEE Frontiers in Education Conference*, November 10 - 13, 1999 San Juan, Puerto Rico.

Stevens R. D., and Edwards A. D. N. An Approach to the Evaluation of Assistive

Technology. *Proceedings of the ACM ASSETS 1996 Conference*. Vancouver, British Columbia Canada

Sánchez, J., Flores, H. (2004a). Memory enhancement through audio. *Proceedings of The Sixth International ACM SIGACCESS Conference on Computers and Accessibility, Assets 2004*, Atantla, Giorgia, USA, October 18-20, pp. 24-31.

Sánchez J., Flores, H. (2004b). AudioMath: Blind Children Learning Mathematics through Audio. *Proceedings of The 5th International Conference on Disability, Virtual Reality and Associated Technologies, ICDVRAT 2004*, September 20-22, Oxford, United Kingdom, pp. 183-189

Contact:
Jaime Sánchez, Ph D.
Department of Computer Science
University of Chile
Blanco Encalada 2120
Santiago, Chile

Presenter: Richard Satava MD

ADVANCED TECHNOLOGIES FOR REHABILITATION

Richard Satava. MD

Telemedicine and Advanced Technology Research Center (TATRC)

Numerous technologies, such as virtual reality, brain-machine devices, nanotechnology, intelligent prosthetics, robotics, and artificial organs to name a few, are opening new opportunities for rehabilitation. Current programs which include exoskeletons and intelligent prostheses for rehabilitation will focus mainly on how the engineering sciences are revolutionizing care of the disabled and disadvantaged. Finally we are able to bring new technologies to restore function and sometimes realistic form for those systems which are lost or incapacitated.

Presenter: Richard Satava MD

THE REVOLUTION IN HEALTHCARE ROBOTICS

Richard Satava, MD

Telemedicine and Advanced Technology Research Center (TATRC)

Robotics has moved from industry to healthcare, creating a new revolution. The concepts behind this profound revolution are discussed, and the various classes of robots are demonstrated, along with their remarkable capabilities - from 'robotic cells' to replacing entire operating room teams, to roving robotic systems and medevacs on the battlefield, to mobile robots (unmanned vehicles) to make rounds for the doctor and nurse. Finally speculation on the logical future that will emerge once these robotic systems are truly embraced by the medical profession

Presenter: Ben Sawyer

GAMES FOR HEALTH: THERAPY AND BEYOND

Ben Sawyer

Woodrow Wilson International Center for Scholars

In the therapy field the use of virtual reality (VR) and game technologies has been a growing force for some years but the greater health field is just tuning in to the possible uses of games and game technologies. The Games for Health project is a Robert Wood Johnson Foundation effort designed to both explore and identify relevant uses for game technologies and the talents that produce them that could offer breakthroughs in healthcare from training, to health messaging, to direct patient application.

During this presentation Ben Sawyer who leads day-to-day activities on the games for health project will discuss the current trends in the games for health field. With the assistance of several other presenters the session will also highlight the logistical and industrial cultural issues which must be hurdled to further the promise game technologies and approaches have shown.

Attendees will not only get a sense of the current best practices but also get a keen sense of the comparative advantages (and disadvantages) game-based approaches are seeking to offer the health field.

PresenterL Thomas Senn

ISLANDS - E -MENTAL HEALTH - TELEPSYCHIATRY

Thomas Senn

COAT-Basel

An overview of the European project ISLANDS will be provided. Which services are feasible and which are desired, which are promising? The ISLANDS project will be embedded in e-health and e-mental health. The persons involved, the services provided and the tools used will then be explained. Different questions will be touched: How can information of counselling and therapy be formalised for persons that are indirectly involved (informal carer) in the therapeutic process? What are the process dynamics within an online therapy? Which patient - therapist relationships can evolve? Which are the limits of e-mental health service provisions?

Within ISLANDS, a cognitive behavioural approach for the therapy module was chosen; other forms of therapy are imaginable. Details about our approaches will be delivered.

Counselling is part of a comprehensive model that is founded on several assumptions about human development: e.g., individuals achieve optimal functioning when they attain operational mastery of fundamental life skills and neurosis and functional psychosis frequently result from failure to develop certain life skills.

Further an overview of technological means in which ISLANDS can be embedded in the future is given. Visions for the future are outlined.

Contact:
Thomas Senn
COAT-Basel
Basel 4025 CH
Tel: +41613255669
Email: ths@coat-basel.com

Presenter: Takanori Shibata PhD

A PROGRESS REPORT OF LONG-TERM ROBOT ASSISTED ACTIVITY AT A HEALTH SERVICE FACILITY FOR THE AGED

Kazuyoshi Wada[1], Takanori Shibata[1,3], Tomoko Saito[1] Kayoko Sakamoto[1] and Kazuo Tanie[2]

[1]Intelligent Systems Research Institute, National Institute Advance Science and Technology (AIST) 1-1-1 Umezono, Tsukuba, Ibaraki 305-8568, JAPAN
[2] National Institute Advance Science and Technology (AIST)
[3]PERESTO, JST

Background

We have proposed Robot-Assisted Therapy and Activity since 1996, and have been developing mental commit robots that provide psychological, physiological, and social effects to human beings through physical interaction[1)9)]. The appearances of these robots look like real animals such as cat and seal. The seal robot, Paro, was developed especially for therapy. We have applied seal robots to therapy of children at pediatric hospitals[4)] and to assisting activity of elderly people at a day service center[5)-7)]. Recently, several research groups have tried robot assisted therapy and activity. Dautenhahn has used mobile robots and robotic dolls for therapy of autistic children[10)]. Besides, robot-assisted activity that uses commercialized animal type robots (such as AIBO[11)], NeCoRo, etc.) has been tried[12)-14)]. For example, Yokoyama used AIBO in a pediatrics ward, and observed the interaction between children and pointed out that the initial stimulus received from AIBO was strong. However, the long term stability was quite weak, compared with living animals[12)]. In this presentation, we will explain the results of the robot-assisted activity for elderly people at a health service facility for the aged for more than *one year.*

Method

In order to investigate the effects of seal robots to the elderly people, we evaluated moods of elderly people by face scales[15)] that express person's moods by illustration of person's faces, questionnaires of Geriatric Depression Scales (GDS)[16)]. Seal robots were provided into the health service facility on two days per a week from Aug. 2003.

Results

The results of face scale and GDS showed that feelings and depression of elderly people

were improved by interaction with the seal robots, Paro. Regarding a case study, Hanako (pseudonym), aged 89, was sociable and comparatively independent. On the first day of the interaction with Paro, she looked a little nervous of the experiment. However, she soon came to like Paro. She treated Paro like her child or grandchild. Her face scale scores after interaction were always lower than before interaction after the first day. Unfortunately, she was hospitalized during Dec. 10 to 26, 2003. When she met Paro for the first time after leaving hospital, she said to Paro "I was lonely, Paro. I wanted to see you again." Her GDS score then improved. To the present, she has continued to join the activity and willingly interacted with Paro. Caregivers commented that interaction with Paro made the people laugh and become more active. For example, their facial expression changed, softened, and brightened. In addition, Paro encouraged the people to communicate, both with each other and caregivers, by becoming their common topic of conversation. Thus, the general atmosphere became brighter.

Conclusions

We have used seal robots, Paro in RAA for elderly people at a health service facility for the aged since August 2003. The results showed that interaction with Paro improved their moods and depression, and then the effects showed up through more than one year. Consequently, the seal robots, Paro were effective for therapy at health service facilities.

T. Shibata, et al., Emotional Robot for Intelligent System - Artificial Emotional Creature Project, Proc. of 5th IEEE Int'l Workshop on ROMAN, pp. 466-471 (1996).

T. Shibata, et al., Emergence of Emotional Behavior through Physical Interaction between Human and Robot, Procs. of the 1999 IEEE Int'l Conf. on Robotics and Automation (1999).

T. Shibata, and K. Tanie, Influence of A-Priori Knowledge in Subjective Interpretation and Evaluation by Short-Term Interaction with Mental Commit Robot, Proc. of the IEEE Int'l Conf. On Intelligent Robot and Systems (2000)

T. Shibata, et al., Mental Commit Robot and its Application to Therapy of Children, Proc. of the IEEE/ASME Int'l Conf. on AIM'01 (July. 2001) paper number 182 and 6 pages in CD-ROM Proc.

T. Shibata, et al., Robot Assisted Activity for Senior People at Day Service Center, Proc. of Int'l Conf. on Information Technology in Mechatronics, pp.71-76, (2001).

K. Wada, et al., Effects of Robot Assisted Activity for Elderly People and Nurses at a Day Service Center, Proc. of the IEEE, Vol.92, No.11, pp.1780-1788 (2004).

T. Saito, et al., Examination of Change of Stress Reaction by Urinary Tests of Elderly before and after Introduction of Mental Commit Robot to an Elderly Institution, Proc. of the 7th Int. Symp. on Artificial Life and Robotics Vol.1 pp.316-319 (2002).

T. Shibata, et al., Tabulation and Analysis of Questionnaire Results of Subjective Evaluation of Seal Robot in Japan, U.K., Sweden and Italy, Proc. of the 2004 IEEE Int. Conf. on Robotics and Automation, pp.1387-1392, (2004).

T. Shibata, Ubiquitous Surface Tactile Sensor, 2004 1st IEEE Technical Exhibition Based Conf. on Robotics and Automation Proc. pp. 5, 6, (2004).

I. Werry and K. Dautenhahn, Applying Mobile Robot Technology to the Rehabilitation of Autistic Children, Proc. of 7th Int. Symp. on Intelligent Robotic Systems, pp.265-272 (1999).

M. Fujita and H. Kitano, An Development of an Autonomous Quadruped Robot for Robot Entertainment, Autonomous Robots, Vol.5, pp.7-18 (1998).

A. Yokoyama, The Possibility of the Psychiatric Treatment with a Robot as an Intervention -From the Viewpoint of Animal Therapy-, Proc. of Joint 1st Int'l Conf. on SCIS & ISIS, paper number 23Q1-1, in CD-ROM Proc. (2002).

E. Libin, and A. Libin, Robotherapy: Definition, Assessment, and Case Study, Proc. of the 8th Int. Conf. on Virtual Systems and Multimedia, pp.906-915 (2002).

E. Ohkubo, et. al. Studies on necessary condition of companion robot in the RAA application, Proc. of 2003 IEEE Int. Sympo. on Computational Intelligence in Robot and Automation, pp.101-106 (2003).

C. D. Lorish, R. Maisiak, The Face Scale: A Brief, Nonverbal Method for Assessing Patient Mood, Arthritis and Rheumatism, Vol.29, No.7, pp.906-909, (1986).

J. A. Yesavage, Geriatric Depression Scale, Journal of Psychopharmacology Bulletin, Vol.24, No.4 (1988).

Contact:
Takanori Shibata
Intelligent Systems Research Institute
National Institute Advance Science and Technology (AIST)
1-1-1 Umezono, Tsukuba
Ibaraki 305-8568, JAPAN
Tel.: +81-29-861-5980
Fax: +81-29-861-5992
Email: shibata-takanori@aist.go.jp

Presenter: Russell Shilling PhD

THE OFFICE OF NAVAL RESEARCH PROGRAM IN VR THERAPY AND THE USE OF "SERIOUS GAMES" AND ENTERTAINMENT TECHNOLOGIES FOR MEDICAL SIMULATION

CDR Russell Shilling, Ph.D.

Office of Naval Research

Increasingly, virtual reality (VR) and videogame technologies are garnering more interest in the medical community. At the Office of Naval Research (ONR), programs have been initiated which look at treatments for combat-related Post-Traumatic Stress Disorder (PTSD) and also evaluate a wide variety of VR medical training platforms. ONR is also assisting the Defense Advanced Research Project Agency (DARPA) in developing innovative treatment options for amputees using videogame technology. One of the underlying philosophies that unify these different programs is the belief that emotion is a crucial component for effective simulation and that lessons learned from the entertainment industry need to be integrated into the development process. In the entertainment industry, sound design is recognized as a critical component in creating emotional content. Until recently, little effort was made to adapt professional sound design techniques commonly used in the entertainment industry for use in simulation. This talk will summarize programs sponsored by ONR to develop VR therapy applications for treating Sailors, Soldiers, and Marines. These PTSD programs will also be discussed in the context of research and development activities conducted by the author while acting as the sound designer, audio engineer, and research psychologist working on the popular videogame, *America's Army*. In the process of developing the audio experience for the game, extensive consultations were made with leading experts and engineers from the movie and videogame industry. As a result, the game has received high reviews in the videogame industry for the quality of sound and has helped the game gain over 4-million registered users worldwide. These same sound design techniques and philosophies need to be incorporated in VR therapy applications to help maximize the emotional impact and increase the sense of immersion in the simulation. Important lessons were also learned concerning the videogame development process and how it relates to creating so-called "serious games" with goals other than entertainment. Current trends in the "serious" use of videogame technologies will be discussed, including the "Games for Health" Project which held its first annual conference in Madison, Wisconsin in 2004.

Contact:
CDR Russell Shilling, Ph.D.
Biological and Medical Science & Technology Division
Office of Naval Research
Arlington, VA 22217
Email: Shilling85@alumni.wfu.edu

Presenter: Viktória Simon MD

CLINICAL EXPERIENCES IN USING VIRTUAL REALITY (VR) IN PSYCHOTHERAPY

[1]Viktória Simon [1]MD, [1]Lajos Simon [1]MD, Phd, , [2]Barnabás Takács Phd

[1]Semmelweis University Budapest, Department of Psychiatry and Psychotherapy
[2]DigitalElite, Los Angeles (CA)

This year our team in the department of psychiatry and psychotherapy of Semmelweis University Budapest had the opportunity to create and try VR in treating phobic patients for the first time in Hungary. The programs that are available for us can be used for the therapy of travel-phobia (subway, driving, bus, airplane), acrophobia, claustrophobia. Beside learning the conditions and tools we make the first steps needed for exposition-therapy together with the patient. We teach also relaxation technics. For controlling the relaxation and the process of the exposition we are monitoring real-time the data of

physiological parameters provided by special biosensors.

After this training period, desensitization takes place in a virtual environment under the control of the therapist. In the different environments the therapist can change the parameters in order to get the phobic stimuli stronger or weaker.

Based on our first pilot-cases and experiences we can enforce that desensitization with VR:

- makes the therapy practically easier to carry out, also easier to control
- can be less dangerous than standard desensitization (thinking about acrophobia for example)
- easier to engage patients for therapy
- drop out is lower than in standard therapies
- the stimuli that reach the patient can be controlled more precisely, the reactions given by the patient to the environment can be measured more precisely.

Contact:
Viktória Simon MD
Semmelweis University Budapest
Department of Psychiatry and Psychotherapy
Fax: +36/1/2100-336
Email: simonviktoria@psych.sote.hu

Presenter: Oliver Stefani

NEXT GENERATION VIRTUAL REALITY SYSTEMS: FUTURE CHALLENGES

Oliver Stefani, Dipl.-Ing. Designer

COAT-Basel, Switzerland

Technologies that directly stimulate the brain to simulate reality still are science fiction. Therefore, current VR technologies are bound to the stimulation of the five human physiological senses. This paper discusses the state of the art of current Virtual Reality (VR) Systems and highlights their barriers and problems. The focus will be on stereoscopic display technologies, CAD-VR integration and interface technologies. We will give insights in the trends of new VR technologies which we identified within *VIEW of the Future*[1] and *INTUITION*[2] and provide some suggestions to improve current VR systems.

Reference

[1] IST-2000-26089
[2] Contract no.: 507248-2

Presenter: Julie St-Jacques

CLINICAL APPLICATIONS OF VIRTUAL REALITY AND CYBERSICKNESS

Julie St-Jacques Ph.D. candidate and Stéphane Bouchard Ph.D.

Université du Québec en Outaouais

For a few years, virtual reality (VR) has made its entry as a new therapeutic method, and more and more studies are documenting its effectiveness, especially for the treatment of anxiety disorders. Cybersickness is the principal counter-indication with the use of this therapeutic method and are also a major concern for many Research Ethics Boards. Very few studies have documented cybersickness in clinical populations and researchers as report very low symptoms. Moreover, our current knowledge on this question is often based on studies conducted either with very different populations (e.g., Navy pilots or astronauts) or with different tasks (e.g., search and rescue, complex motor tasks). These may not generalize well to clinical populations and therapeutic tasks. It is therefore important to document cybersickness in a way that is useful and applicable to clinical situations.

The goal of this study is to document cybersickness by collecting systematic data in children and adults. The sample of non phobic participants consisted of 23 children and 34 adults. Questionnaire and head motion data were recorded. In order to compare if the cybersickness reported by non phobics are equivalent with those reported by phobic participants, data from adult phobics are also used.

The results revealed few cybersickness symptoms. When comparing children and adults separately, there's no significant difference in cybersickness reported. A significant correlation is found between discomfort related to VR and the amplitude of head movements performed during the VR immersion. Finally, the relatively low level of

cybersickness reported is comparable between phobics and non phobics. The results obtained illustrate that VR is safe when used with healthy participants as well as when all the precautions to ensure there comfort are taken.

Contact:
Julie St-Jacques Ph.D. candidate
Université du Québec en Outaouais
23 Pharand Gatineau J9A 1K7
Canada
Tel: 1-819-771-7761 X 8392
Fax: 1-819-776-8098
Email: juliestjacques@netscape.net

Presenter: Hubert Sulzenbacher MD

TELECOMMUNICATION IN PSYCHIATRY: A NEEDS ASSESSMENT OF DIFFERENT POTENTIAL USER GROUPS IN THE "ISLANDS" PROJECT

Dr. Hubert Sulzenbacher

Department of Psychiatry
Medical University Innsbruck, Austria

Geography influences access to mental health-care. There are some regions in the European Union with particular geographical characteristics, which are responsible for their being behind the average socio-economic development in Europe. In such regions there is a lack of access to modern health-care facilities, especially psychiatric and psychotherapeutic therapies. Telecommunication technologies, such as the telephone, interactive television, and the Internet, can provide feasible tools for diagnostic, counseling and therapy purposes to improve mental health-care in such disadvantaged areas. One has to differentiate between several users' needs. Persons who are suffering from a certain disorder are looking for different information, seeking different forms and content of help than their family members, partners, or friends do. All of them are involved in the disorder and its consequences. So are professionals who sometimes need advice, especially in state of the art treatment adjusted to their specific environment. "ISLANDS", a project funded by the Commission of the European Union (QLRT-2001-01637), aims to develop services to provide modular, remote psychiatric and psychotherapeutic assistance for remote areas. By these means quality of life of the users, quality of mental health care and the economic strength of the region should improve and overweight the costs of implementation and service support. In the project a questionnaire was developed to identify the needs of the potential user groups of such a service. This questionnaire was given to patients, family members, and therapists in five European regions to find relevant differences between urban centers and remote rural regions. The results of this survey showed a dissatisfying situation of mental health-care as well as of diffusion of telecommunication technologies in remote regions. We found little knowledge about and little experience with telepsychiatry and e-mental health, but all potential user groups showed positive attitudes towards the psychiatric use of telecommunication media, and most users were interested having a telepsychiatric or e-mental health service available.

Contact:
Dr. Hubert Sulzenbacher
Department of Psychiatry
Medical University
Anichstrasse 35
Innsbruck 6020, Austria
Phone: 004351250423668
Fax: 004351250423628
Email: ullrich.meise@uklibk.ac.at

Presenter: Ioannis Tarnanas PhD

AROUSED AND IMMERSED: INTRODUCING "VIRTUAL PAIN" INTO AN EXTREME TEAM TRAINING EXPERIENCE

Ioannis Tarnanas PhD

Kozani University of Applied Science, Greece

Biocybernetics approaches for promoting human-system compatibility continuously adjust the challenge level of a task to match the available resources of the human operator based on his/her psycho physiological state. This project expands the scope of biocybernetics to teams. The objective of this project was to test the effectiveness of a selected training intervention enabled by VE technology. The training intervention that was selected was the use of an advanced team human-computer interface to enhance VE training effectiveness. Specifically, this project tested the effects of one operator's psy-

cho-physiological fear and anxiety measures, to another operator's explicit display of control "difficulty", represented in a force feedback Joystick ("virtual pain"), to handle cues in a counter strike wargame simulation. Prior research work indicated that social psycho physiological compliance can predict team performance in a projective tracking task (Tarnanas, et al., 2003). Two instructional VE were presented. One VE was using the explicit biocybernetic interface that challenged the self-efficacy and team decision making of the operators in a crisis situation scenario, by linking their heart rates (ECG), electrodermal activity (EDA) and electromyogram measurements of facial muscle tensions (EMG) with a Force Feedback Joystick of controlled "ease" of movements while engaged in a joint task. The second VE was the same team crisis situation environment as the above, but without the introduction of the advanced biocybernetic interface. In both the scenarios the operators had the freedom to communicate verbally while engaged in the common task. Two performance measures were computed: (a) RMS error, and (b) number of groundings. Analyses of RMS error scores indicate that performance improved over the three repeated runs with each VE, as evidence of specific-channel learning. Similarly, performance improved on the first run from Day 1 to Day 2, as evidence of near-transfer learning. However, the advanced biocybernetic interface provided to the first experimental group, provided an additional important statistical performance improvement relative to the "simple" VE group and the control groups. The mapping between the type of user-operator state and the type of medium response also had an influence on the level of presence. This project suggests that social-psychophysiological measures and team biocybernetics merit further investigation in sociotechnical systems that demand high proficiency and self-efficacy.

Contact:
Ioannis Tarnanas PhD
Kozani University of Applied Science
Thessalonica, 1st Emm. Papa street
55236 Kozani, Greece
Phone: +302310344831
Fax: +302310344810
Email: ioannist@auth.gr

Presenter: Sharon Tettegah PhD

EXPLORING ANIMATED NARRATIVE VIGNETTE TECHNOLOGY TO UNDERSTAND EMPATHY, AGGRESSION AND RACIAL IDEOLOGIES WITH MIDDLE SCHOOL YOUTHS

Sharon Tettegah, Ph.D., Helen Neville, Ph.D.

University of Illinois, Urbana Campaign

Research status: Completed Preliminary Clinical Trials

Background

Relational aggression, such as name calling and other epithets, remain in today's school environments. Despite the effort to reduce relational aggression (name-calling, eye rolling, etc.) in schools, such behaviors continue to pervade our classroom and subject students to forms of unnecessary victimization. This study begins with a personal narrative of an eleven year old African American female, which was developed into a web-based animated narrative vignette (ANV). An ANV is a scenario that expresses a real life experience that mimics a situation (Tettegah, 2002, 2003, 2004). As a research and teaching tool, other types of
vignettes tend to be positively received by both scholars and educators and the use of vignettes has been empirically validated to help students achieve educational goals on a variety of technical, social, and behavioral topics (Barter & Renold, 2000; Finch, 1987; Chau et al., 2001; Mosquera, Manstead & Fischer, 2002; Schoenberg & Ravdal, 2000; Sleed, Durrheim, Kriel, Soloman, et al., 2002;). Our research leverages the storytelling process of creating an ANV by using technology and will leverage the deliverables of that storytelling process, the vignettes, to understand how students perceive, in this paper, an incident in the classroom (multiple types of ANVs have been created with different foci). This research sought to answer the following questions: Is ANV technology a viable fidelity to measure student responses to social, anti-social and behavioral dispositions?

Method

Participants. One hundred and four middle school students (N= 55 males, N = 45 females, 4 unidentified) in the inner city Chicago area participated in this study. Students

were in the 7th and 8th grade (N= 30, 7th graders and N = 70, 8th graders, 4 unidentified). Qualitative data analysis revealed the following categories:

Racism = acknowledgement of racism or racial prejudice occurring in the vignette (0 = no acknowledgement; 1 = acknowledgement)
Empathy = participant expressed empathy toward the victim in the vignette (0 = no expressed empathy; 1 = expressed empathy)
Response = how the participant would respond to the situation. There are three rows representing physical aggression, verbal response, and tell authority. Physical Aggression (first row) -- 1 = response includes some form of physical aggression (e.g., hit, beat up, etc.); 0 = no physical aggression Verbal Response (second row)-- 1 = participant indicated verbally responding to Scott (e.g., inquired about his intentions and thinking, insult him, etc.); 0 = no verbal response Tell Authority (third row)-- 1 = participant would respond by telling an authority figure (e.g., teacher, principal, parent); 0 = no mention of telling authority Affect = self identified affect or personal feelings of the participant
(e.g., acknowledging personally feeling mad, angry, hurt, offended, etc.) (0 = no acknowledged affect; 1 = acknowledged affect)

Results

Data analysis suggested that students interpreted the situation using ANV technology as a methodological tool was effective. The student's were able to take on the perspectives of character(s) in the ANV and respond in ways that suggest perspective taking and problem solving.

Novelty/Discussion

Prior work in this area focused on pre-service teachers (Tettegah, 2002, 2003, 2004). Our research provides the first systematic evaluation of the use of an ANV technology as a methodological tool with middle school students to understand how students perceive classroom conflict.

References

Barter, C. & Renold, E. (2000). I wanna tell you a story; exploring the application of vignettes in qualitative research with children and young people. International Journal of Social Re search, 3(4). 307-323

Finch, J. (1987). The vignette technique in survey research. Sociology, 21(1). 105-114

Chau, J., Chang, A., Lee, I., Ip, W., Lee, D., & Wootton, Y. (2001). Effects of using videotaped vignettes on enhancing students' critical thinking ability in a baccalaureate nursing programme. Journal of Advanced Nursing, 36(1), 112-119.

Mosquera, P.M., Manstead, A.S.R., & Fischer, A.H. (2002) the role of honour concerns in emotional reactions to offences. Cognition and Emotion, 16(1). 143-163

Schoenberg, N.E., & Ravdal, H. (2000). Using vignettes in awareness and attitudinal research. International Journal of Social Research Methodology, 3(1).63-74

Sleed, M., Durrheim, K., Kriel,A., Soloman,V., & Baxter, V. (2002). The effectiveness of vignette methodology: A comparison of written and video vignettes in eleiciting responses about date rape. South African Journal of Psychology, 32(3).
Tettegah, S. (2002b). Teachers, identity, psychological capital, and electronically mediated representations of cultural consciousness. In
Proceedings of the 14th Ed-Media World Conference on Educational Multimedia, Hypermedia and Telecommunications (pp. 337-340).

Denver, CO. Tettegah, S. & Kien, G. (2003, April) Identity, Human-Computer-Interaction, and Teacher Voices. Paper presented at the
Annual Meeting of American Educational Research Association Conference, Chicago, IL

Tettegah, S. (2004, August). Pre-service teachers problem solving and victim empathy; What about Jamilah? Poster presented at the Annual Meeting of the American Psychological Association.

Contact:
Sharon Tettegah, Ph.D.
University of Illinois, Urbana Campaign
383 Education, MC 708, 1310 S. Sixth Street
Illinois, United States
Phone: (217) 265-6206
Fax: (217) 244-4572
Email: stettega@ad.uiuc.edu

Presenter: Dave Thomas PhD

NIDA'S VIRTUAL REALITY PAIN RESEARCH PROGRAM

Dave Thomas, PhD

National Institutes on Health
National Institute on Drug Abuse

The National Institute on Drug Abuse (NIDA) has an annual budget of about a billion dollars, and is the largest drug abuse research funding entity in the world. NIDA supports basic drug abuse research, clinical trials of anti-addiction medications, and research on community interventions for drug abuse prevention and treatment. NIDA also supports many other areas of research that are related to drug abuse. One example of this is NIDA's extensive pain research program. NIDA's interest in pain research is many fold, and includes research on why many pain killers are addictive, how to make analgesics that are less addictive, and the development of effective non– pharmacological pain treatments. Included in this later category are treatments using acupuncture, transcutaneous electrical nerve stimulation (TENS), and virtual reality (VR). NIDA's VR and pain program is in its infancy, yet a number of projects have been funded that have demonstrated efficacy of VR in the treatment of various types of pain, including dental pain, burn pain, and pain encountered during physical therapy. NIDA is also funding research for the use of VR, along with fMRI imaging, to allow people with chronic pain to control the brain areas responsible for their pain, thereby reducing their perception of chronic pain. At NIDA, VR is envisioned as a powerful tool that can be used to help many of the millions of people living life with chronic pain.

Presenter: Cheryl Y. Trepagnier PhD

VIRTUAL ENVIRONMENTS TO ADDRESS AUTISTIC SOCIAL DEFICITS

Cheryl Y. Trepagnier, Ph.D., Marc M. Sebrechts, Andreas Finkelmeyer, Maya Coleman, Willie Stewart, Jr., Monica Werner-Adler.

The Catholic University of America

Research Status: The paper describes research in progress.

Background

Autistic Disorder is defined by social and communicative impairments and restricted, narrow interests. Impaired motivation is also common.

Several investigators have developed computer-based and virtual environment tools to address various issues in autism(1-5). Four projects at CUA address the social impairment.

Method/Tools

Face Processing: The prediction that autistic face processing impairment involves gaze differences was tested in an eye tracking study using a VR display. A replication in progress uses a monitor.

Early Intervention: A virtual environment, with kiddie-ride, monitor display and eye tracker, is being tested. The goal is to induce young children with autism to attend to faces.

Social Navigation: A joystick-navigable, first-person-perspective shopping mall is presented on a monitor. To locate objects, the user must move either between or around social and non-social obstacles. Data include user comments and path records.

Training in Social Conversation: SIMmersion LLC™ are collaborating with us to develop a social conversation module for adults with Asperger's Disorder. A virtual character remembers the conversation and responds as would an actual interlocutor to the user's speech.

Results

Face Processing: Preliminary results (with headset) confirmed gaze differences(6). The replication is in progress. Early intervention: Reliability-testing is being completed. Social Navigation: Controls describe their avatar's actions in the first person, and refrain from walking between conversing characters. Data collection with persons with autism has begun. Training in Social Conversation: Development is in progress

Discussion

The projects described above derive from the hypothesis that failure to establish species-

typical face attention and processing itself undermines cognitive development(7). Accordingly face processing is targeted in young children, and compensatory training is addressed with older individuals. The challenge is to make the technology not only effective, but adequately entertaining to overcome autistic motivational barriers.

References

(1) Max ML, Burke JC. (1997). Virtual reality for autism communication and education, with lessons for medical training simulators. Stud Health Technol Inform. 39:46-53.
(2) Parsons S, Mitchell P. (2002). The potential of virtual reality in social skills training for people with autistic spectrum disorders. J Intellect Disabil Res. 46(Pt 5):430-43.
(3) Parsons S, Mitchell P, Leonard A. (2004). The use and understanding of virtual environments by adolescents with autistic spectrum disorders. J Autism Dev Disord. 34 (4):449-66.
(4) Strickland D, Marcus LM, Mesibov GB, Hogan K. (1996). Brief report: two case studies using virtual reality as a learning tool for autistic children. J Autism Dev Disord. 26 (6):651-9.
(5) Strickland D. (1997). Virtual reality for the treatment of autism. Stud Health Technol Inform. 44:81-6.
(6) Trepagnier C, Sebrechts MM, Peterson R. (2002). Atypical face gaze in autism. Cyberpsychol Behav. 5(3):213-7.
(7)Trepagnier C. (1996). A Possible Origin for the Social and Communicative Deficits of Autism. Focus on Autism and Other Developmental Disabilities. 11(3):170-82.

Contact:
Cheryl Y. Trepagnier, Ph.D.,
The Catholic University of America,
Washington, DC, USA
Tel: 1 (202) 319-5780
Fax: 1 (202) 319-6162
Email: trepagnier@cua.edu

Presenter: Mimi M.Y.Tse PhD

AFFECTIVE IMAGES: RELIEVING CHRONIC PAIN AND ENHANCING QUALITY OF LIFE FOR OLDER PERSONS

Mimi M.Y.Tse PhD, RN, Sandra P.Y. Pun, , BSN, RN, MHA, Iris F.F.Benzie, DPhil, FIBMS

The Hong Kong Polytechnic University

Background/Problem

With increasing life expectancy, the incidence of chronic illness and chronic pain also increase. Chronic pain robs older people of their quality of life, limits functional mobility and ambulation, and this lead to muscle atrophy. The older persons are reluctant to request pain relief, attempting to endure pain as 'normal' part of ageing. Chronic pain and mobility difficulties interact among older person; causing a negative feedback loop in which reducing physical activity to avoid pain usually ends up a further increase in pain when activity is undertaken. To this end, the innovative non-pharmacological intervention in pain management is appealing.

Method/Tool

Affective images and pictures were used in 15 elderly (12 female and 3 male, ages ranged 60 to 80, median age 71) in chronic pain and needed to perform stretching and standing exercises in their physiotherapy session. The affective picture book was made according to the preference of the older persons. The images included Chinese snack food and dim sum; market areas; landmark of the city; transportation system; flowers and natural scenery as well as images and pictures of previous famous movie stars. There were about 60 images and pictures in the picture book.

Pain scores were measured by Visual Analogue Scale (VAS) and health-related quality of life was measured by Medical Outcomes Study Short Form 36 (SF 36). VAS and SF-36 were taken in week 1 and in week 6. Pain scores were measured during physiotherapy session in following weeks.

Results

Before the intervention, pain intensity was found to be severe (median pain scores was 50 on a 100mm VAS). There was a significant decreased of VAS from week 1 to week 6 ($t = 3.607$; $df = 14$; $p < 0.05$). Also, a significant decreased in VAS when the older persons were watching affective pictures while performing the physiotherapy exercise in the 2nd and 3rd week; but not over the 4th and 5th week. SF-36 had been increased in

week 6 which indicated an increased in health-related quality of life, despite not statistically significant.

Discussion/Conclusion

The study demonstrated a decreased in pain perception and increased in health-related quality of life among the older persons with chronic pain. Before the intervention, pain was severe enough to hinder their activities of daily living, decreasing the desire to participate in exercise and social events.

Regular physical activity is important to health. With the use of affective images and pictures, the older persons tend to report less pain; became more cooperated and increased the mobility level during and after the physiotherapy session. In this regard, affective images and pictures appear to be an effective non-pharmacological intervention in pain management for the older persons, of which, their mobility and quality of life would be enhanced.

Novelty

There has not been any research and application of affective images and pictures as an adjunct to pain relief for older population. Our study adds knowledge to existing pain relief methods.

Contact:
Mimi M.Y.Tse
School of Nursing
The Hong Kong Polytechnic University
Phone:852 2766 6541
Fax: 852 2364 9663
Email: hsmtse@inet.polyu.edu.hk

Presenter: Dimitrios Tzovaras PhD

HAPTIC ACCESS TO VIRTUAL MODELS OF REAL DATA FOR TRAINING THE VISUALLY IMPAIRED

K. Moustakas, G. Nikolakis, D. Tzovaras and M.G. Strintzis

Informatics and Telematics Institute/CERTH

Research Status: Completed.

This paper presents a completed novel framework for haptic interaction with 3D virtual scenes automatically generated from a video captured by a single camera. The system is used for training visually impaired users.

Background/Problem

The combination of two different and complementary modalities like haptics and video is a very challenging research area. The potential benefits of such a combination for the visually impaired people are very high [1], since they will be able to navigate in unknown for them places without risking injuries etc., as will be described in the sequel.

Method/Tools

Initially, bi-directional 2D motion estimation is performed on the video. Rigid 3D motion and structure is recovered using an object based reconstruction approach, which makes use of extended Kalman filtering (EKF), utilizing also a basic knowledge of the scene. The resulting 3D structure data are used to generate the 3D model of the processed scene. This is accomplished either by generating a single mesh of the scene utilizing the generated depth maps, or by applying modeling for the objects of the scene using analytical implicit functions and non-linear least squares minimization. The generated model is used in order to provide haptic access to the processed scene for the blind using haptic devices like the PHANToM and the CyberGrasp.

Results

In order to evaluate the proposed methods, experiments were performed on 3D real maps of buildings as well as indoor maps. The camera captures the map and the system converts the monoscopic video into a 3D model. Finally, the blind user navigates through the map using the haptic devices [2]. The experiments demonstrated the efficiency of the proposed methods. The system performs in real time and if there exists knowledge about the captured scene, like the case with the 3D maps, the scene can be approximated using implicit functions and computationally intensive processes like collision detection are performed 20-30 times faster, when compared to standard mesh based methods.

Usability Studies

The proposed haptic interaction system has been also evaluated in tests with users of the Blind Association in Thessaloniki, Greece. The system evaluation results have shown that users consider it very innovative and satisfactory in terms of providing realistic and smooth force feedback. The percentage of the satisfied users was reported to be more than 96\%. Analysis of variance (ANOVA) test were also performed and illustrated interesting statistical results (i.e. the gender does not affect the performance results of the user, there exists a difference in performance for users which were born blind). These tests are not presented in detail due to space restrictions.

Conclusion

In terms of novelty the proposed framework combines video with haptics in a real time framework for the generation of virtual scenes, which are then used to train visually impaired people, on how to navigate in specific areas. Moreover it extends structure from motion (SfM) methods and combines them with surface approximation schemes using implicit surfaces, thus resulting in an efficient, realistic and user-friendly system.

References

[1] D. Tzovaras and G. Nikolakis and G. Fergadis and S. Malasiotis and M. Stavrakis, "Design and Implementation of Haptic Virtual Environments for the Training of Visually Impaired", IEEE Transactions on Neural Systems and Rehabilitation Engineering, vol. 12, no. 2, pp. 266-278, June 2004.
[2] G.C. Burdea, "Force and touch feedback for virtual reality" Wiley-Interscience Publication 1996.

Contact:
D. Tzovaras
Informatics and Telematics Institute/CERTH
1st km Thermi Panorama Road
Thermi-Thessaloniki, 57001 Greece
Phone: +302310464160
Fax:+302310464164
Email: moustak@iti.gr

Presenter: Dimitrios Tzovaras PhD

HAPTIC INTERFACE FOR THE PERFORMANCE OF A REMOTE ECHOGRAPHY EXAMINATION

K. Moustakas, G. Nikolakis, D. Tzovaras and M.G. Strintzis

Informatics and Telematics Institute/CERTH

Research Status: Completed.

The proposed paper describes a force feedback control system for the performance of remote ultrasound examination.

Background/Problem

During the last few years, there have been a lot of efforts to use and integrate virtual environments in medical applications. Such works have been developed in order to improve the performance of specific medical applications. In our case, a 3D virtual environment is developed to provide the expert with a realistic simulation of remote ultrasound examination. The proposed paper describes the force feedback [1] control aspects of a remote ultrasound examination system. The haptic interface is used by an ultrasound specialist in order to control a robotic system and perform a remote ultrasound examination.

Method/Tools

The PHANToMT [2] fictive probe can provide sufficient data for the control of the robot, which is located at the remote site, and offers the capability to use force feedback to assist the expert performing the echography examination. In the proposed virtual reality 3D environment a menu provides the user/expert with the ability to select between a variety of actions and functionalities. Specifically, the user can view a representation of the workspace. The user in the expert site can simply import appropriate 3D geometries from VRML files. The expert can select the examination working area using the PHANToMT Stylus and start/stop the examination process. When the expert selects the examination area an automatic scaling occurs so that the active PHANToMT workspace size can access all the workspace of the slave robot, using a uniform scale factor. When the expert starts the examination, the force feedback is applied to the expert via PHANToMT depending on the force measured by the slave robot located at the remote station. The 3D model can be also used as an alternative

source for providing this force feedback input to the PHANToMT device, in cases of weak communication links. For safety reasons, if the PHANToMT probe penetrates the 3D graphical model over a threshold value, an alarm sound is activated to warn the expert for possible communication failure. The use of a master probe and slave robot brings up the problem that they have different workspaces. Using scaling can solve the problem of different workspaces. If scaling is applied only to the positions and the forces felt by the human remain the same, as measured at the remote site, then the appearing stiffness of the environment changes due to the scaling factor "s". In order to solve this problem scaling is also performed to the force feedback.

Results

The system was integrated with a communication system for the transmission of ultrasound images and video and it was tested. The results have shown that the doctors appreciated the haptic feedback when the communication bandwidth was good enough to provide feedback to the user without noticable delay.

Conclusion

In this paper, we presented a new 3D virtual reality environment with force feedback control and inspection of ultrasound examination. The system was successfully integrated and tested to a Tele-Echography environment.

Reference

[1] G.C. Burdea, "Force and touch feedback for virtual reality" Wiley-Interscience Publication 1996.
[2] Sensable Technologies Inc., http://www.sensable.com/

Contact:
D. Tzovaras
Informatics and Telematics Institute/CERTH
1st km Thermi Panorama Road
Thermi-Thessaloniki, 57001 Greece
Phone: +302310464160
Fax:+302310464164
Email: moustak@iti.gr

Presenter: Efisia Urru PhD

PROJECT IR

Dr. Efisia Urru

L'Associazione Medica Italiana per lo Studio della Ipnosi (A.M.I.S.I)

This is a time to venture for hypnotherapy. All things change in a human being. The strange link between us and machines is a reality today. Milton Erickson gives us a lesson for the coming years. His mysterious work, only in this millennium appears as a secret code that will be revealed to the new generation. With the case of "February Man" it is possible for us to give a new interpretation to it. This is a new era for hypnosis. Do we stand by? Our answer is in this work the PROJECT IR in which for the first time hypnosis is utilized with virtual reality. Therapist and patients together live in a virtual program. In this project synthesis there are two possible programs. One is the development of relaxation with a standard program of virtual reality for all people that want to remove themselves out of their daily life. This program is made for a psychologist's clinic or in the future when it will be available as a videogame in personal homes. Two is a specific virtual reality program for grave pathology such as phobias, depression, psychosis, and schizophrenia.

This virtual reality program is made after studying a deep history of patience. Each program has the same key of opening and closure with particularly pictures.

Contact:
Dr. Efisia Urru
L'Associazione Medica Italiana per lo Studio della Ipnosi (A.M.I.S.I)
Street lamarmora 38
Sardinia Cagliari Italy
Tel: 3477762318
Email: efisia.urru@inwind.it

Presenter: Cecilia Vera MSc

WEARABLE SYSTEM FOR AUTOMATIC EMOTION DETECTION IN EXTREME CONDITIONS

Cecilia Vera MSc

SIEMENS, S.A.

In the recent years the automatic detection of

human emotions has been one of the areas of interest within the scientific community. Most of the studies published so far are based on a combination of two techniques: advanced image-processing and codification of expressions. This second approach is based on the theories that postulate the existence of basic and universal emotions and establish a relationship between these basic emotions and certain facial expressions. Up to now, a good strategy for detecting a subject emotion has been the analysis of facial images to determine the expressions shown by the individual, and the subsequent codification of these expressions in terms of basic emotions. Nevertheless, this abstract brings up an innovative method for the detection and recognition of human emotions: the processing of biomedical signals.

This novel technique has been the origin of the AUBADE project (partially funded by the EC IST programme) that aims to develop an intelligent, multi-sensor and wearable system for the assessment of the emotional state of humans under special or extreme conditions. The emotions are detected after the processing of electromyogram (EMG) measurements obtained from the face of the person to be assessed. Additionally other biomedical signals are considered: hearth rate variability, skin conductivity and respiration rate. This approach means an alternative to the traditional image-processing techniques and makes possible the application of the system in a wider number of situations, especially in those were it is not achievable to have facial images available. The project, now in progress, involves the utilization of innovative technologies, such as wearable devices, biosensors, data fusion, medical decision support systems, 3-D animation and telecommunications.

The result of the project will be a modular and multifunctional system to be applicable in diverse areas. In the health sector, it is expected that it will contribute to improve the diagnosis of neurological diseases as well as to get a better comprehension of the psychological status of patients through the emotion detection. It will be used to monitor people under high levels of stress or special conditions, making possible to assess the effects that these conditions produce to their emotional state. The system will also establish relations between facial expressions and certain diseases, helping health professionals to gain knowledge in this area and increasing the efficiency in diagnosis.

AUBADE project will develop the next generation of the remote emotion's monitoring systems, providing health professionals with an innovative tool that will lead them to a deep study, analysis, understanding, and comprehension of human emotions.

Contact:
Cecilia Vera MSc
SIEMENS, S.A.
Ronda de Europa, 5. Tres Cantos.
Madrid 28070, Spain
Phone: + 34 91 514 45 84
Fax: +34 91 514 47 87
Email: cecilia.vera@siemens.com

Presenter: Erik Viirre MD PhD

ADAPTIVE DISPLAYS: CAN WE PREDICT PERFORMANCE?

Erik Viirre M.D. Ph.D.[1], Tzyy-Ping Jung Ph.D.[1], Bradley Chase Ph.D.[2], Yi-Fang Tsai[3], Shawn Wing[3], Christopher Strychacz[3]

[1] University of California, San Diego
[2] University of San Diego
[3] Naval Health Research Center, San Diego

Research Status: In Progress.

Background

Adaptive displays are often envisioned as systems that respond to state changes in an operator. To date, physiologic measures are typically averaged over a window of some duration, often several minutes, to develop statistical certainty on the onset of a state change. We are interested in determining the possibility of using physiologic measures to more directly predict the onset of performance changes during tasks. To do so, we are examining oculomotor changes as they precede performance on a dual auditory and visual tracking task. In line with previous studies in this area (1,2), we anticipate that a number of oculomotor behaviors will change with performance and that an aggregate measure will have higher predictive power that an individual measure. Our aspiration is to be able to monitor oculomotor activity, perhaps combined with other behavior measures, to detect work overload conditions

where errors might occur. Such approaches would be applicable to situations such as the common driving-while-talking-on-the-phone and could be used to warn drivers that their attention is overloaded.

Method/Tools

Eye movements and head were recorded EyeLink II from SR Research. The interactive STIÒ fixed-base driving simulator developed by Systems Technology, Inc. with custom visual scenes were used for a curving mountain-driving scenario. Participants were asked to maintain lane position between two moving vehicles a fixed distance apart. The secondary task was a version of the Paced Auditory Serial Addition Test (PASAT). Subjects hear a series of numbers, mentally add a number to the previous number and verbally state the sum. Difficulty is varied as a function of number presentation speed. A typical number presentation rate of 1.8 seconds results in approximately 60% correct responses. The subjects were instructed to perform three ten-minute block trials of driving, auditory, and the dual tasks. Eye movement behaviour characteristics including those of blinks, saccades, vergence eye movements and pupil diameter are all being examined for their statistical relation to the correct or incorrect responses on the audio task and to the variability on the driving performance task.

Results

Preliminary data analysis has progressed to description of overall comparisons of performance on the combined task compared to the individual driving or audio task. Comparison of performance on the auditory task alone versus with driving showed that there was small, non-significant decrease in performance with the dual-task. Blink durations increased in the combined task versus the driving task alone, but actually substantially increased during the auditory task alone. Further, the variability of blink duration showed a similar pattern. Further analyses are ongoing.

Conclusion/Discussion

We hope that this study will provoke discussion as to the feasibility of using physiologic measures as direct predictors of performance as opposed to general indicators of operator state. Improved prediction could lead to advanced adaptive interfaces and direct improvements in performance. If predictive measures can be described for our particular tracking/audio task, it will be important to determine how generalizable our model of cognitive overload and our metrics can be for other high work-load conditions.

References

Van Orden K., Limbert W., Makeig S., and Jung T-P, "Eye Activity Correlates of Workload during a Visualspatial Memory Task", Human Factors, 43(1):111-21, 2001.

Van Orden K, Jung T-P, and Makeig S, "Combined eye activity measures accurately estimate changes in sustained visual task performance," Bio Psych, 52:221-40, 2000

Contact:
Erik Viirre M.D. Ph.D.
University of California, San Diego
Department of Cognitive Science
Tel: 858 336-0317
Fax: 858 270 0740
Email: eviirre@ucsd.edu

Presenter: Daniela Villani

VIRTUAL REALITY TO REDUCE ANXIETY IN HEALTHY POPULATION: THE RELAXATION ISLAND

Daniela Villani[1]; Francesco Riva[2]; Eva L. Waterworth, Ph.D.[3]; John Waterworth, Ph.D.[4]; Jonathan Freeman, Ph.D.[5]; Giuseppe Riva, Ph.D.[1].

[1] Applied Technology for Neuro-Psychology Lab, Istituto Auxologico Italiano, Milan, Italy
[2] Center for Communication Psychology, Catholic University of the Sacred Heart, Milan, Italy
[3] Tools for Creativity Studio, The Interactive Institute, Umeå, Sweden
[4] Department of Informatics, Umeå University, Umeå, Sweden
[5] Department of Psychology, Goldsmith College, University of London, UK

The use of Virtual Reality in therapy is not a novelty [1] and we expect that, combined with different relaxation techniques, it can enhance the relaxation by visually presenting, and thereby enhancing, key images for facilitating relaxation and acceptance, and enabling par-

ticipants to practice, and hence master, relaxation and acceptance techniques in a more realistic context.

The aim of the study is to explore whether the effects on mood, specifically on anxiety and positive and negative states, of a therapeutic narrative enhance through its presentation within a virtual environment [2] in an immersive condition.

To accomplish this goal we use the Relaxation Island in which we apply different relaxation techniques, following a specific protocol that is composed by two sessions. Three phases compose each session: the first is based on immersive navigation in the day, the second on imagination and the third on immersive navigation in the night.

The techniques aim to reduce anxiety linked to active negative thinking through cognitive control and to achieve progressive muscular relaxation following the approach proposed by Jacobson [3] and the breathing techniques. To test the enhance of the effects we compare this procedure with an usually video procedure, a new age DVD with relaxing music, where participants watch a video and have the freedom to imagine any sensory element required. Some of the questionnaires used are *Positive and Negative Affect Schedule* (PANAS), to measure the positive and negative affects [4], and *State Trait Anxiety Inventory* (STAI), to measure the level of anxiety[5]. Participants, University students, were 30 subjects ranging from 21 to 24 years old, split up in two groups. The study is in progress and the results will be ready in march, therefore preliminary outcomes will be presented during the conference.

References

Riva, G., Wiederlhold K. B. and Molinari E. (Eds), (1998) *Virtual Environment in Clinical Psychology and Neuroscience*. Amsterdam: IOS Press

Freeman, J., Lessiter, J., Keogh, E., Bond, F.W., & Chapman, K. (2004) *Relaxation Island: virtual, and really relaxing. 7th International Workshop on Presence/ Presence 2004, 13-15 October. Universitat Politecnica de Valencia, Spain.*

Jacobson, E. (1938) *Progressive Relaxation*. Chicago. U. of Chicago Press

Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., & Jacobs, G. A. (1983) Manual for the State-Trait Anxiety Inventory (Form Y). Palo Alto, CA: Mind Garden

Watson, D.; Clark, L.A.; Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality & Social Psychology, 54(6)*

Contact:
Daniela Villani
Applied Technology for Neuro-Psychology Lab
Istituto Auxologico Italiano
Via Pelizza da Volpedo 41
Milan, Italy
Ph./Fax +39-02619112892
Email: d.villani@auxologico.it

Presenter: Tamar Weiss PhD

THE VIRTUAL MALL: A FUNCTIONAL VIRTUAL ENVIRONMENT FOR STROKE REHABILITATION

Debbie Rand M.Sc[1,3], Noomi Katz Ph.D[2], Rachel Kizony M.Sc [1,2,3,4], Meir Shahar MBA[3], Patrice L. (Tamar) Weiss Ph.D[1,3]

[1] Department of Occupational Therapy, University of Haifa
[2] School of Occupational Therapy, Hadassah-Hebrew University, Jerusalem
[3] Laboratory for Innovations in Rehabilitation Technology
[4] Dept of Occupational Therapy, Sheba Medical Center, Tel Hashomer

Research Status: In Progress

Background

Patients who have had a stroke constitute a large population with significant needs for rehabilitation. To date, even after long, intensive and costly rehabilitation, these patients still suffer from many impairments leading to severe restrictions of participation in every day life. In addition, there is insufficient training of instrumental activities of daily living (IADL) functioning during the rehabilitation, since it is both time consuming and technically difficult to implement. There is a great advantage to remediate motor and executive function deficits via practicing tasks that are functional, meaningful to the patient, and which can be repeated over and over again in a safe environment. A Virtual Mall (VMall) has been designed to be used for the treat-

ment of patients following a stroke who have motor and/or executive functions deficits (1).

Aims

1) To describe the development of a functional virtual environment, the Virtual Mall. 2) To present data from a pilot study of stroke patients which assessed the suitability of the VMall for this population, and 3) To present the data of an initial clinical trial which examines the effectiveness of the VMall environment for the assessment and treatment of executive functions deficits and motor deficits.

Method

Participants: For testing the suitability of the VMall, six patients, aged 50-74 years, who had sustained a stroke more than two years prior to the study were pilot-tested. For the pilot clinical trial stroke patients, aged 50-85 years, who had sustained a stroke at least three months prior to the study will be recruited. The patients all suffer either from a considerable motor impairment of their upper extremity (assessed using the Fugl-Meyer Motor Assessment) and/or from deficits in their executive functions (assessed using two subtests from the Behavioral Assessment of the Dysexecutive syndrome (BADS) (2)). *Instruments:* The VMall (to date one large store with multiple aisles), has been implemented via VividGroup's (www.vividgroup.com) video capture Gesture Xtreme system (GX). The performance of the task provides multiple opportunities to make decisions, plan strategies and multitask, all in a fairly intuitive manner. Shopping for grocery products is done by virtually touching the different items located on shelves in different aisles. Output measures record the user's performance with in the VMall and the kinematics of the patient's movements. *Procedure:* A single case study design (ABA) will be used to assess the effectiveness of treatment using the VMall.

Initial Results/Conclusion

Initial performance data and feedback from the patients suggest that the VMall provides an interesting and motivating task. Detailed results of the initial clinical trial will be presented and further development of the VMall paradigm will be discussed.

Novelty

In comparison to functional virtual environments that are presented on desktop VR systems or those which use a Head-mounted Display, the use of a video capture platform for the development of a virtual functional environment is advantageous since it encourages patients to actively move their affected upper extremity in a relatively functional manner while planning, initiating, and problem solving when engaged in the shopping task.

References

1. Weiss, P.L., Rand, D., Katz, N., & Kizony, R. (2004). Video capture virtual reality as a flexible and effective rehabilitation tool. *Journal of NeuroEngineering and Rehabilitation,* 1:12.
2. Wilson, B.A., Alderman, N., Burgess, P.W., Emslie, H., & Evans, J.J., (1996). *Behavioral Assessment of the Dysexecutive syndrome.* Bury St. Edmunds: Thames Valley Test Company.

Presenter: Marc Wolter PhD

NEUROMAN – A COMPREHENSIVE SOFTWARE SYSTEM FOR NEUROPSYCHOLOGICAL EXPERIMENTS

Jakob T. Valvoda, Torsten Kuhlen, Marc Wolter, Claudia Armbrüster, Will Spijkers, Rene Vohn, Walter Sturm, Bruno Fimm, Martina Graf, Ines Ann Heber, Hans-Christoph Nuerk, Klaus Willmes

Virtual Reality Group, Center for Computing and Communication, RWTH Aachen University

Background/Problem

Virtual Reality (VR) is an established neuroscientific instrument. Several approaches to develop software systems for particular neuropsychological experiments exist, like navigation[1] or driving assessment.[2] An overview is given.[3] In other studies game engines have been used.[4] These systems are in general limited to a specific field of application. When experimental paradigms are changed, the software has to be re-designed. In neuropsychological studies exact runtime behaviour of the software has to be guaranteed and measured as well as the responses of participants within millisecond accuracy, features that are not provided in most existing

approaches. Finally, some of the systems only allow execution on desktop-based systems, lacking immersive, stereoscopic visualization.

In order to use Virtual Reality in the broad field of neuropsychological research, and to meet diverse needs and requirements of neuropsychological researchers, we have developed the NeuroMan system, a comprehensive software framework. NeuroMan enables the user to describe experimental set-ups and their runtime behaviour in a versatile and easy way and to monitor the responses of participants. With our approach we have handled the challenges of diversity of experimental set-ups, chronological logging, and heterogeneous virtual environments.

Method/Tools

The design of NeuroMan is based on the principle, that a description of the experimental set-up and its chronological performance should be separated from the implementation of VR-methods and their particular implementation on VR-hardware. In NeuroMan experimental set-ups are defined by scripts.[5] The system generates a virtual experiment with the desired application flow, i.e., a sequence of sessions, blocks, trials and multimodal stimuli, which may be influenced by specified user interactions or system events. The resulting experiments can be executed on a variety of VR-hardware, making use of the VR-toolkit ViSTA, and its multimedia extensions.[6] Main features of NeuroMan are the possibility to log the overall system behaviour with specific timing characteristics[7] and to handle large environmental models as visual stimuli. Integration of acoustics, human avatars, and fMRI scanner support are being developed in current projects.

Results

We have conducted several neuropsychological experiments with NeuroMan, e.g., research on mental representations of numbers,[8] on attentional asymmetries after sleep deprivation[9] and for the assessment and treatment of disorders of spatial representations. In a further study we investigated distance estimation in VR.[10] Studies concerning the influence of language properties on object manipulation and the modulatory effects of attention on pointing and grasping movements are currently underway. The experiments described have been carried out on table-like displays, on a HoloBench™, in a 5-sided CAVE-like environment and with a head-mounted display. Electro-magnetic and optical tracking systems have been used.

Conclusions

NeuroMan has been used successfully in several neuropsychological studies. The script language with its underlying experimental model is capable of describing various experimental set-ups

Novelty/Discussion

Even though several approaches to the development of software systems for neuropsychological experiments have been utilized, a comprehensive software framework for VR-based experiments has not been established yet. NeuroMan is capable of handling a variety of experiments on a comprehensive and homogeneous basis.

Reference

[1] Mallot, HA und Gillner, S: Route navigation without place recognition: What is recognized in recognition-triggered responses? Perception 29, 43-55, 2000

[2] Wald JL, Liu L, Reil S: Concurrent Validity of a Virtual Reality Driving Assessment for Persons with Brain Injury. CyberPsychology & Behavior, 3(4): 643-654, 2000

[3] Riva G: Virtual environments in neuroscience. IEEE Transactions on Information Technology in Biomedicine 2(4), 275 - 281, 1998

[4] Burgess N, Maguire EA, Spiers HJ, O'Keefe J: A temporoparietal and prefrontal network for retrieving the spatial context of lifelike events. NeuroImage, 14(2):439-453, 2001

[5] Valvoda JT, Assenmacher I, Dohle C, Kuhlen T, Bischof C. NeuroVRAC - A comprehensive approach to virtual reality-based neurological assessment and treatment systems. Medicine meets Virtual Reality 11, Los Angeles, 2003

[6] Assenmacher I, Kuhlen T, Lentz T, Vorländer M.: Integrating Real-Time Acoustics into VR-Applications. Proc. Eurographics/ACM SIGGRAPH Symposium Virtual Environments, Grenoble, 2004

[7] Valvoda JT, Assenmacher I, Kuhlen T, Bischof CH. Reaction-Time Measurement and Real-Time Data Acquisition for Neuroscientific Experiments in Virtual

Environments. Medicine Meets Virtual Reality 12, Newport Beach, CA, 2004
[8] Graf M, Nuerk HC, Valvoda JT, Kuhlen T, Willmes K: Wie sind Zahlen mental im 3D-Raum repräsentiert? In Rammsayer T, et al. (Edt.), 44. Kongress der Deutschen Gesellschaft für Psychologie, p. 297, Lengerich: Pabst, 2004
[9] Heber IA, Valvoda JT, Kuhlen T, Sturm W, Fimm B: Asymmetries of visuo-spatial attention in virtual space after sleep deprivation. 12th Annual Cognitive Neuroscience Society (CNS) Meeting, New York, NY, 2005, (accepted abstract)
[10] Armbrüster C, Heber IA, Valvoda JT, Kuhlen T, Fimm B, Spijkers W: Distance Estimation in a VR application: inter-individual differences and intra-individual stabilities from a psychological point of view. Proccedings of the 11th international Conference on Human-Computer Interaction, 2005, (in press)

Contact;
Jakob T. Valvoda,
Virtual Reality Group, Center for Computing and Communication, RWTH Aachen University
52074 Aachen, Germany
valvoda@rz.rwth-aachen.de
Tel: +49 – 241 – 80-243 76
Fax: +49 – 241 – 80-221 34

Presenter: Christine Youngblut PhD

PRESENCE-- SETTING THE SCENE

Christine Youngblut PhD

Institute for Defense Analyses

Much attention has been focused on feeling a sense of *presence* in a virtual environment (VE). The potential importance of presence is based on an assumption that increasing the sense of presence experienced in a VE leads to improved task performance.

The goal of this informal talk is to set the scene for the following presentations by introducing the presence construct. It will summarize the results of over 120 studies that have been conducted by various researchers over the last decade. Critical outstanding research questions will be identified, along with some recommendations for future presence research.

Presenter: Brenda K. Wiederhold PhD MBA BCIA

VR FOR BLOOD-INJECTION-INJURY PHOBIA

Brenda K. Wiederhold[1,2], Megan Mendoza[1], Tadashi Nakatani[1],
Alex H. Bullinger[3], Mark D. Wiederhold[1]

[1] Virtual Reality Medical Center, San Diego, California
[2] Interactive Media Institute, San Diego, California
[3]COAT-Basel/UPKBS, University of Basel, Switzerland, Department of Psychiatry

Virtual reality (VR) exposure therapy has been shown to be successful in treating many types of specific phobias which are mostly visual in nature. However, limited research has been completed on the use of VR therapy for Blood Injection-Injury (BII) phobias, one of the subtypes of Specific Phobia listed in the DSM-IV TR. Since BII phobia may operate by some tactile component, it may respond differently to VR therapy compared to other categories of specific phobias that are largely visually activated. This paper discusses initial development and results from a study on both subjective and objective arousal elicited by a prototype virtual world which has been developed to treat those with BII phobia. The present study evaluated the responses of 20 healthy, non-phobic male and female participants to VR blood and injection stimuli. Initial results are positive and show that the VR world delivers appropriate cues to elicit physiological and self-reported arousal when exposed to the injection scenarios. Correlations between self-reported anxiety and physiological arousal confirm that individuals experiencing greater symptoms of fear in conditions involving blood or injections will exhibit more intense arousal from the virtual stimuli than those who experience reduced symptoms. Findings suggest that the virtual world is an effective method of cue exposure for individuals who experience anxiety in situations related to blood and injections. Future research on the use of VR exposure therapy in the treatment of BII phobia is warranted.

Contact:
Brenda K. Wiederhold
Interactive Media Institute
6160 Cornerstone Court East, Suite 161

San Diego, CA 92121
Ph: (866) 822-8762
Fax: (858) 642-0285

Presenter: Feryel Znaïdi

TOWARDS A COGNITIVE AND SENSORIAL MODEL OF PRESENCE: A STUDY IN DIFFERENT VIRTUAL SENSORY CONDITIONS

Feryel Znaïdi, MA, Olivier Warusfel, Roland Jouvent, IsabelleViaud-Delmon

CNRS UMR 7593

Presence is the experience a person has, when in a virtual environment (VE), of 'being there.' Presence is an important concept to assess the effectiveness of a virtual environment in clinical applications. We designed an experiment in which the importance of different factors that might contribute to the feeling of presence could be evaluated. Three kinds of VEs in which different sensory information were provided to the subjects were tested and compared. Subjects were equipped with a head-mounted display coupled with an electromagnetic sensor system and immersed in a virtual town in which they could move forward by pressing a mouse button. Subjects had to turn on their own vertical axis in order to change the direction of heading in the virtual town. Their task was to locate different landmarks and become familiar with the town. After this virtual navigation, they had to fill in a presence scale, a state anxiety scale, a cyber sickness symptoms scale, and complete several spatial memory tests related to their experience. Subjects had to perform this navigation according to three conditions (Vis, Avis, and A) during separate sessions. In the AVis condition subjects were equipped with the head-mounted display and headphones, which delivered a soundscape updated in real time according to their movement in the virtual town. In the third condition, they were asked to navigate in a soundscape in the absence of vision (A). The sounds were produced through tracked binaural rendering (HRTF) and were dependent upon the subject's movements. During all conditions, skin conductance was recorded.

Contact:
Feryel Znaïdi, MA
CNRS UMR 7593
PARIS FRANCE
Phone: + 33 1 42 16 12 59
Fax: + 33 1 53 79 07 70
Email: znaidi@ext.jussieu.fr